Appendix D

DRAINAGE REPORT AND STORM WATER MANAGEMENT PLAN

DRAINAGE REPORT

For

WESTFIELD CARLSBAD
Carlsbad, CA

May 6, 2010
Revised: July 5, 2012

Prepared By:

Hofman Planning & Engineering
3152 Lionshead Ave.
Carlsbad, CA 92010

REGISTERED PROFESSIONAL ENGINEER
HAIXIN LI
No. C59064
Exp. 6/30/13
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Haixin Li, P.E. RCE 59064 Exp: 06/30/13

Prepared by: HL

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OBJECTIVE

The objective of this study is to determine the stormwater runoff generated in a 100-year event for both the existing and proposed conditions on the site and compare with the hydraulic capacity of the existing storm drain system. Moreover, this study will also design the proposed storm drain system to effectively control the runoff while mitigating impacts to the downstream storm drain facilities.

PROJECT DESCRIPTION

The 80.94 acre Specific Plan Boundary site is located at 2525 El Camino Real. The site is bounded by State Highway 78 and Buena Vista Creek to the north, El Camino Real to the east, commercial development to the west and Marron Road and residential development to the south.

The site is fully developed with a comprehensive storm drain system. The site drains away from the central building to the storm drain system along Marron Road and Buena Vista Creek.

PROPOSED IMPROVEMENTS

The existing shopping center is being revitalized. The western portion of the main building will be re-configured and expanded to accommodate new tenants. New outlying building and parking are being proposed as well. The project area (limits of work) for these proposed improvements total 18.03 acres or 22.2% of the total site.

RESULTS

With this expansion, the impervious area within the 18.03 acre project area (limits of work) decreased from 15.91 acres to 13.33 acres. The percentage of impervious area decreased from 88.2% to 73.9%. As there is a net decrease in impervious area, we have determined that the inlet capacities of the storm drain system are sufficient to convey runoff from a 100-year storm event.

100-yr runoff flow rates are calculated for the 8 proposed on-site drainage areas. The proposed vegetated swales are sufficient to convey the 100-yr flow as show in the attached calculations.

Furthermore, we have modified the storm drain system so that the 100-year runoff generated from the proposed development will not adversely impact the downstream facilities any more than what has previously been constructed.

CERTIICATION

This Drainage Report has been prepared by HPE. I attest to the technical information contained herein and the engineering data upon which recommendations and conclusions are based.

Haixin Li, P.E.
RCE 59064

07/05/2012
Date

Swale-10FT-100Yr

Channel Calculator

Given Input Data:

Shape .... Trapezoidal
Solving for .... Flowrate
Slope .... 0.0109 ft/ft ← Worst Case
Manning's n 0.0220
Depth .... 7.0000 in
Height .... 8.0000 in
Bottom width .... 72.0000 in
Left slope .... 0.3333 ft/ft (V/H)
Right slope .... 0.3333 ft/ft (V/H)

Computed Results:

Flowrate .... 19.1786 cfs ← at 7" Depth
Velocity .... 4.2422 fps
Full Flowrate .... 24.3847 cfs ← at 8" Depth
Flow area 4.5209 ft2
Flow perimeter .... 116.2759 in
Hydraulic radius .... 5.5989 in
Top width .... 114.0042 in
Area 5.3335 ft2
Perimeter .... 122.6010 in
Percent full .... 87.5000 %

Critical Information

Critical depth .... 7.3496 in
Critical slope .... 0.0092 ft/ft
Critical velocity .... 3.9954 fps
Critical area 4.8002 ft2
Critical perimeter .... 118.4870 in
Critical hydraulic radius .... 5.8338 in

Swale-10FT-100Yr

Critical top width .... 116.1019 in
Specific energy .... 0.8630 ft
Minimum energy .... 0.9187 ft
Froude number 1.0842
Flow condition .... Supercritical

Swale-5FT-100Yr

Channel Calculator

Given Input Data:

Shape	Trapezoidal
Solving for	Flowrate
Slope	0.0210 ft/ft ← Worst Case
Manning's n	0.0220
Depth	4.0000 in
Height	6.0000 in
Bottom width	24.0000 in
Left slope	0.3333 ft/ft (V/H)
Right slope	0.3333 ft/ft (V/H)

Computed Results:

Flowrate	3.8161 cfs ← at 4" Depth
Velocity	3.8159 fps
Full Flowrate	8.3283 cfs ← at 6" Depth
Flow area	1.0000 ft2
Flow perimeter	49.3005 in
Hydraulic radius	2.9210 in
Top width	48.0024 in
Area	1.7501 ft2
Perimeter	61.9507 in
Percent full	66.6667 %

Critical Information

Critical depth	4.7310 in
Critical slope	0.0111 ft/ft
Critical velocity	3.0410 fps
Critical area	1.2549 ft2
Critical perimeter	53.9244 in
Critical hydraulic radius	3.3510 in

Swale-5FT-100Yr

Critical top width .... 52.3891 in
Specific energy .... 0.5596 ft
Minimum energy .... 0.5914 ft
Froude number 1.3455
Flow condition .... Supercritical

San Diego County Rational Hydrology Program

CIVILCADD/CIVILDESIGN Engineering Software,(c)1991-2006 Version 7.7

Rational method hydrology program based on
San Diego County Flood Control Division 2003 hydrology manual
Rational Hydrology Study Date: 05/10/12

HOFMAN PLANNING AND ENGINEERING
PRELIMINARY DRAINAGE REPORT
WESTFIELD CARLSBAD
SITE DEVELOPMENT PERMIT SDP-0904

********* Hydrology Study Control Information **********

Program License Serial Number 6152

Rational hydrology study storm event year is 100.0
English (in-lb) input data Units used

Map data precipitation entered:
6 hour, precipitation(inches) = 2.650
24 hour precipitation(inches) = 5.000
P6/P24 = 53.0%
San Diego hydrology manual 'C' values used

```
++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
Process from Point/Station      100.000 to Point/Station      110.000
**** INITIAL AREA EVALUATION **** Area A1
______________________________________________________________________
Decimal fraction soil group A = 0.000
Decimal fraction soil group B = 0.000
Decimal fraction soil group C = 0.000
Decimal fraction soil group D = 1.000
[COMMERCIAL area type                       ]
(Office Professional    )
Impervious value, Ai = 0.900
Sub-Area C Value = 0.850
Initial subarea total flow distance  =  560.000(Ft.)
Highest elevation =   46.000(Ft.)
Lowest elevation =   40.000(Ft.)
Elevation difference =    6.000(Ft.) Slope =  1.071 %
INITIAL AREA TIME OF CONCENTRATION CALCULATIONS:
The maximum overland flow distance is 60.00 (Ft)
for the top area slope value of   1.07 %, in a development type of
 Office Professional
In Accordance With Table 3-2
Initial Area Time of Concentration =   3.70 minutes
 (for slope value of   1.00 %)
The initial area total distance of  560.00 (Ft.) entered leaves a
remaining distance of  500.00 (Ft.)
Using Figure 3-4, the travel time for this distance is   5.36 minutes
for a distance of 500.00 (Ft.) and a slope of  1.07 %
with an elevation difference of   5.36(Ft.) from the end of the top area
Tt = [11.9*length(Mi)^3)/(elevation change(Ft.))]^.385 *60(min/hr)
 =    5.362 Minutes
Tt=[(11.9*0.0947^3)/(  5.36)]^.385=  5.36
Total initial area Ti =   3.70 minutes from Table 3-2 plus
  5.36 minutes from the Figure 3-4 formula =   9.06 minutes
Rainfall intensity (I) =     4.758(In/Hr) for a   100.0 year storm
Effective runoff coefficient used for area (Q=KCIA) is C = 0.850
Subarea runoff =     14.033(CFS)
Total initial stream area =       3.470(Ac.)
```

```
++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
Process from Point/Station     200.000 to Point/Station     210.000
**** SUBAREA FLOW ADDITION **** Area A2
______________________________________________________________________
Rainfall intensity (I) =     4.758(In/Hr) for a   100.0 year storm
Decimal fraction soil group A = 0.000
Decimal fraction soil group B = 0.000
Decimal fraction soil group C = 0.000
Decimal fraction soil group D = 1.000
[COMMERCIAL area type                     ]
(Office Professional    )
Impervious value, Ai = 0.900
Sub-Area C Value = 0.850
Time of concentration =     9.06 min.
Rainfall intensity =     4.758(In/Hr) for a   100.0 year storm
Effective runoff coefficient used for total area
(Q=KCIA) is C = 0.850  CA =     5.304
Subarea runoff =    11.202(CFS) for     2.770(Ac.)
Total runoff =    25.235(CFS) Total area =      6.240(Ac.)
```

```
++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
Process from Point/Station     300.000 to Point/Station     310.000
**** SUBAREA FLOW ADDITION **** Area A3
______________________________________________________________________
Rainfall intensity (I) =     4.758(In/Hr) for a   100.0 year storm
Decimal fraction soil group A = 0.000
Decimal fraction soil group B = 0.000
Decimal fraction soil group C = 0.000
Decimal fraction soil group D = 1.000
[COMMERCIAL area type                    ]
(Office Professional    )
Impervious value, Ai = 0.900
Sub-Area C Value = 0.850
Time of concentration =    9.06 min.
Rainfall intensity =     4.758(In/Hr) for a   100.0 year storm
Effective runoff coefficient used for total area
(Q=KCIA) is C = 0.850  CA =     9.341
Subarea runoff =    19.210(CFS) for     4.750(Ac.)
Total runoff =    44.445(CFS) Total area =     10.990(Ac.)
```

```
++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
Process from Point/Station     400.000 to Point/Station     410.000
**** SUBAREA FLOW ADDITION **** Area A4
______________________________________________________________________
Rainfall intensity (I) =     4.758(In/Hr) for a   100.0 year storm
Decimal fraction soil group A = 0.000
Decimal fraction soil group B = 0.000
Decimal fraction soil group C = 0.000
Decimal fraction soil group D = 1.000
[COMMERCIAL area type                    ]
(Office Professional    )
Impervious value, Ai = 0.900
Sub-Area C Value = 0.850
Time of concentration =    9.06 min.
Rainfall intensity =     4.758(In/Hr) for a   100.0 year storm
Effective runoff coefficient used for total area
(Q=KCIA) is C = 0.850  CA =    11.467
Subarea runoff =    10.110(CFS) for     2.500(Ac.)
Total runoff =    54.555(CFS) Total area =     13.490(Ac.)
```

```
++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
Process from Point/Station     500.000 to Point/Station     510.000
**** SUBAREA FLOW ADDITION **** Area A5
______________________________________________________________________
Rainfall intensity (I) =     4.758(In/Hr) for a   100.0 year storm
Decimal fraction soil group A = 0.000
Decimal fraction soil group B = 0.000
Decimal fraction soil group C = 0.000
Decimal fraction soil group D = 1.000
[COMMERCIAL area type                    ]
(Office Professional    )
Impervious value, Ai = 0.900
Sub-Area C Value = 0.850
Time of concentration =    9.06 min.
Rainfall intensity =     4.758(In/Hr) for a   100.0 year storm
Effective runoff coefficient used for total area
(Q=KCIA) is C = 0.850  CA =    12.538
Subarea runoff =     5.096(CFS) for     1.260(Ac.)
Total runoff =    59.651(CFS) Total area =     14.750(Ac.)
```

```
++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
Process from Point/Station     600.000 to Point/Station     610.000
**** SUBAREA FLOW ADDITION **** Area A6
______________________________________________________________________
Rainfall intensity (I) =     4.758(In/Hr) for a   100.0 year storm
Decimal fraction soil group A = 0.000
Decimal fraction soil group B = 0.000
Decimal fraction soil group C = 0.000
Decimal fraction soil group D = 1.000
[COMMERCIAL area type                    ]
(Office Professional    )
Impervious value, Ai = 0.900
Sub-Area C Value = 0.850
Time of concentration =    9.06 min.
Rainfall intensity =     4.758(In/Hr) for a   100.0 year storm
Effective runoff coefficient used for total area
(Q=KCIA) is C = 0.850  CA =    15.759
Subarea runoff =    15.327(CFS) for     3.790(Ac.)
Total runoff =    74.978(CFS) Total area =     18.540(Ac.)
```

```
++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
Process from Point/Station      700.000 to Point/Station      710.000
**** SUBAREA FLOW ADDITION **** Area B1
______________________________________________________________________
Rainfall intensity (I) =      4.758(In/Hr) for a   100.0 year storm
Decimal fraction soil group A = 0.000
Decimal fraction soil group B = 0.000
Decimal fraction soil group C = 0.000
Decimal fraction soil group D = 1.000
[COMMERCIAL area type                    ]
(Office Professional    )
Impervious value, Ai = 0.900
Sub-Area C Value = 0.850
Time of concentration =     9.06 min.
Rainfall intensity =     4.758(In/Hr) for a   100.0 year storm
Effective runoff coefficient used for total area
(Q=KCIA) is C = 0.850  CA =     16.507
Subarea runoff =      3.559(CFS) for      0.880(Ac.)
Total runoff =     78.537(CFS) Total area =      19.420(Ac.)
```

```
++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
Process from Point/Station     800.000 to Point/Station     810.000
**** SUBAREA FLOW ADDITION **** Area B2
______________________________________________________________________
Rainfall intensity (I) =     4.758(In/Hr) for a   100.0 year storm
Decimal fraction soil group A = 0.000
Decimal fraction soil group B = 0.000
Decimal fraction soil group C = 0.000
Decimal fraction soil group D = 1.000
[COMMERCIAL area type                    ]
(Office Professional    )
Impervious value, Ai = 0.900
Sub-Area C Value = 0.850
Time of concentration =    9.06 min.
Rainfall intensity =     4.758(In/Hr) for a   100.0 year storm
Effective runoff coefficient used for total area
(Q=KCIA) is C = 0.850  CA =    17.255
Subarea runoff =     3.559(CFS) for     0.880(Ac.)
Total runoff =    82.096(CFS) Total area =     20.300(Ac.)
End of computations, total study area =        20.300 (Ac.)
```

LEGEND

- EXISTING BOUNDARY
- EXISTING RIGHT OF WAY
- EXISTING BUILDING
- EXISTING STORMDRAIN (UNDER 12")
- EXISTING STORMDRAIN (15" TO 24")
- EXISTING STORMDRAIN (30" TO 48")
- EXISTING STORMDRAIN (ABOVE 48")
- EXISTING DITCH
- EXISTING CONTOUR
- EXISTING DRAINAGE BASIN
- LIMITS OF WORK (PROJECT AREA)
- PROPOSED RAINAGE DIRECTION
- PROPOSED BULDING

DRAINAGE BASIN DATA		
DESCRIPTION	AREA (SF)	AREA (AC)
BASIN 1	343,904	7.89
BASIN 2	3,157,567	72.49
BASIN 3	11,764,036	270.07
LIMITS OF WORK	659,934	15.15

NOTE:

BACKGROUND IMAGES ARE NOT TO SCALE AND ARE FOR VISUAL REPRESENTATION ONLY. IMAGES ARE PART OF THE CITY OF CARLSBAD MASTER PLAN OF DRAINAGE FACILITIES, 2007, PLATES A-1 AND A-2.

EXISTING TOPOGRAPHICAL BASE MAP WAS PROVIDED BY WESTFIELD.

Prepared By:

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No	Revision	Date

Key Plan:

Westfield
PLAZA CAMINO REAL
2525 El Camino Real # 100
Carlsbad, CA 92008
(760) 729-7927

WESTFIELD DESIGN & CONSTRUCTION
11601 Wilshire Boulevard, 11th Floor
Los Angeles, California 90025-1748
Telephone 310 478 4456
Facsimile 310 478 4468

Sheet Title
EXISTING BASIN ANALYSIS

ENTITLEMENT PACKAGE
SDP 09-04

Job No.	Date	Scale
1080	05/06/2010	1"=300'

EXHIBIT-1

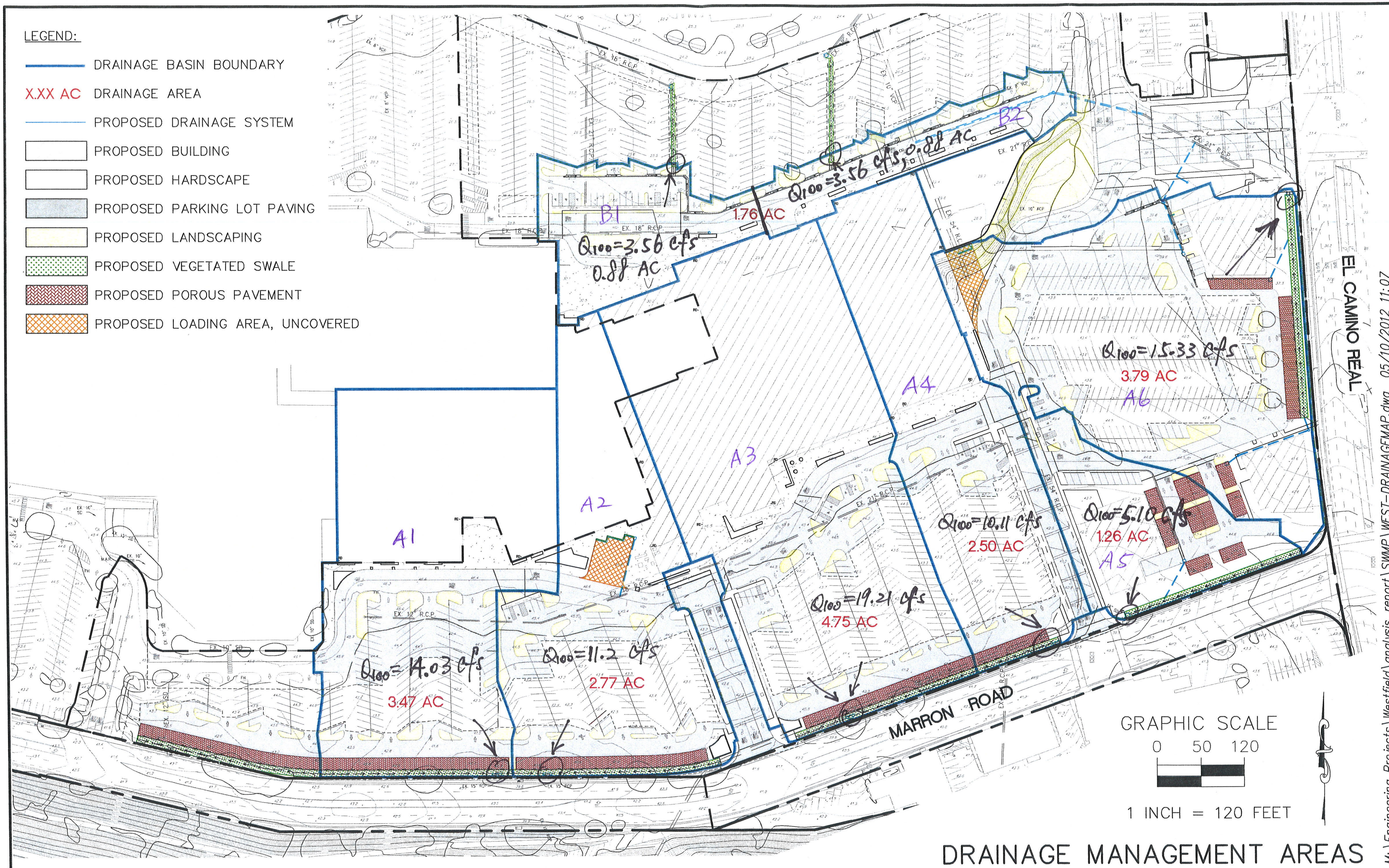
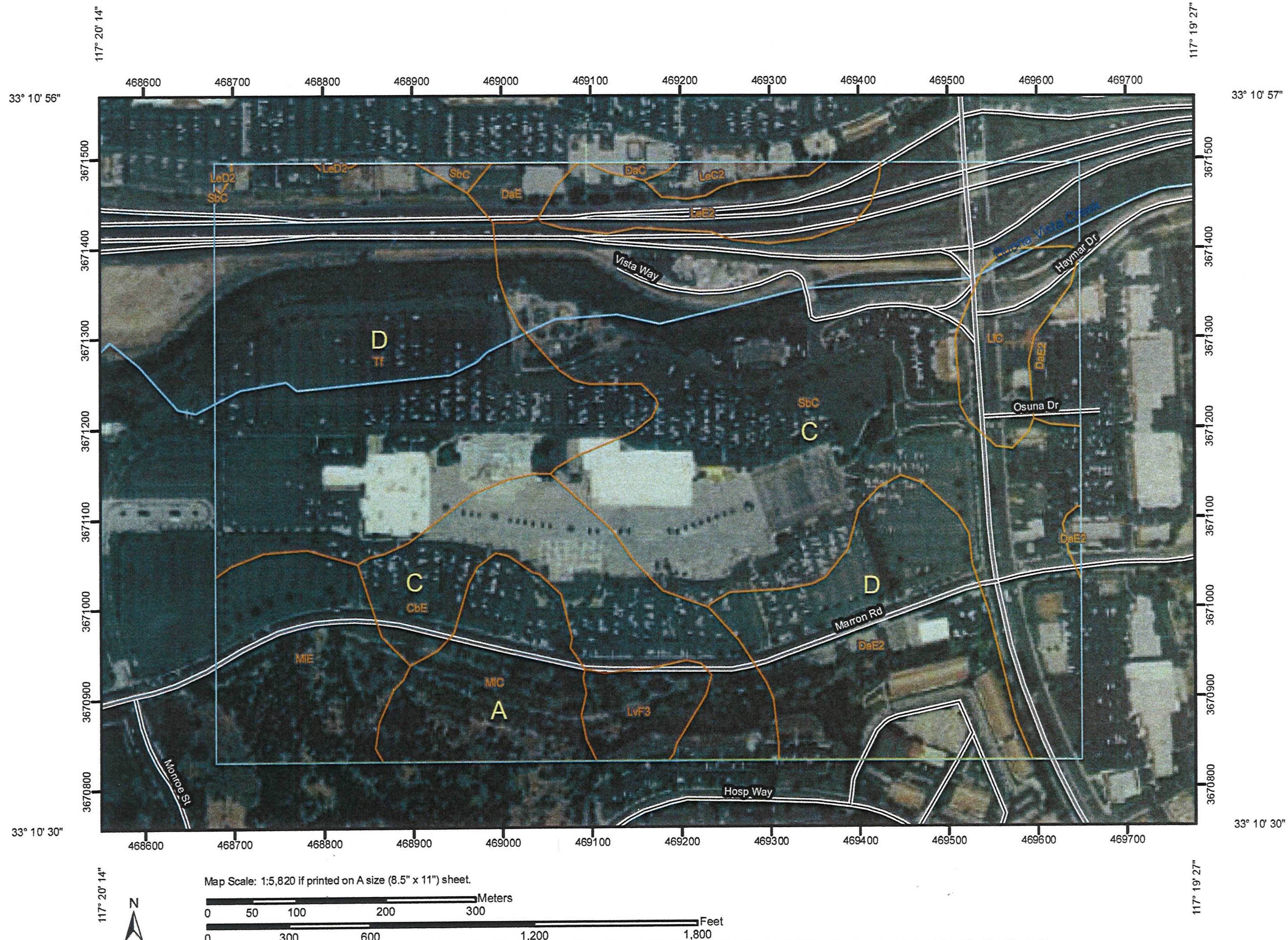

LEGEND:
DRAINAGE BASIN BOUNDARY
X.XX AC DRAINAGE AREA
PROPOSED DRAINAGE SYSTEM
PROPOSED BUILDING
PROPOSED HARDSCAPE
PROPOSED PARKING LOT PAVING
PROPOSED LANDSCAPING
PROPOSED VEGETATED SWALE
PROPOSED POROUS PAVEMENT
PROPOSED LOADING AREA, UNCOVERED
B1
Q100=3.56 cfs
0.88 AC
B2
Q100=3.56 cfs, 0.88 AC
1.76 AC
A1
Q100=14.03 cfs
3.47 AC
Q100=11.2 cfs
2.77 AC
A2
A3
Q100=19.21 cfs
4.75 AC
A4
Q100=10.11 cfs
2.50 AC
A5
Q100=5.10 cfs
1.26 AC
A6
Q100=15.33 cfs
3.79 AC
EL CAMINO REAL
MARRON ROAD
GRAPHIC SCALE
0 50 120
1 INCH = 120 FEET
DRAINAGE MANAGEMENT AREAS
M:\Engineering Projects\Westfield\analysis_report\SWMP\WEST-DRAINAGEMAP.dwg 05/10/2012 11:07

EXHIBIT 2



HYDROLOGIC SOIL GROUPS ARE IN YELLOW

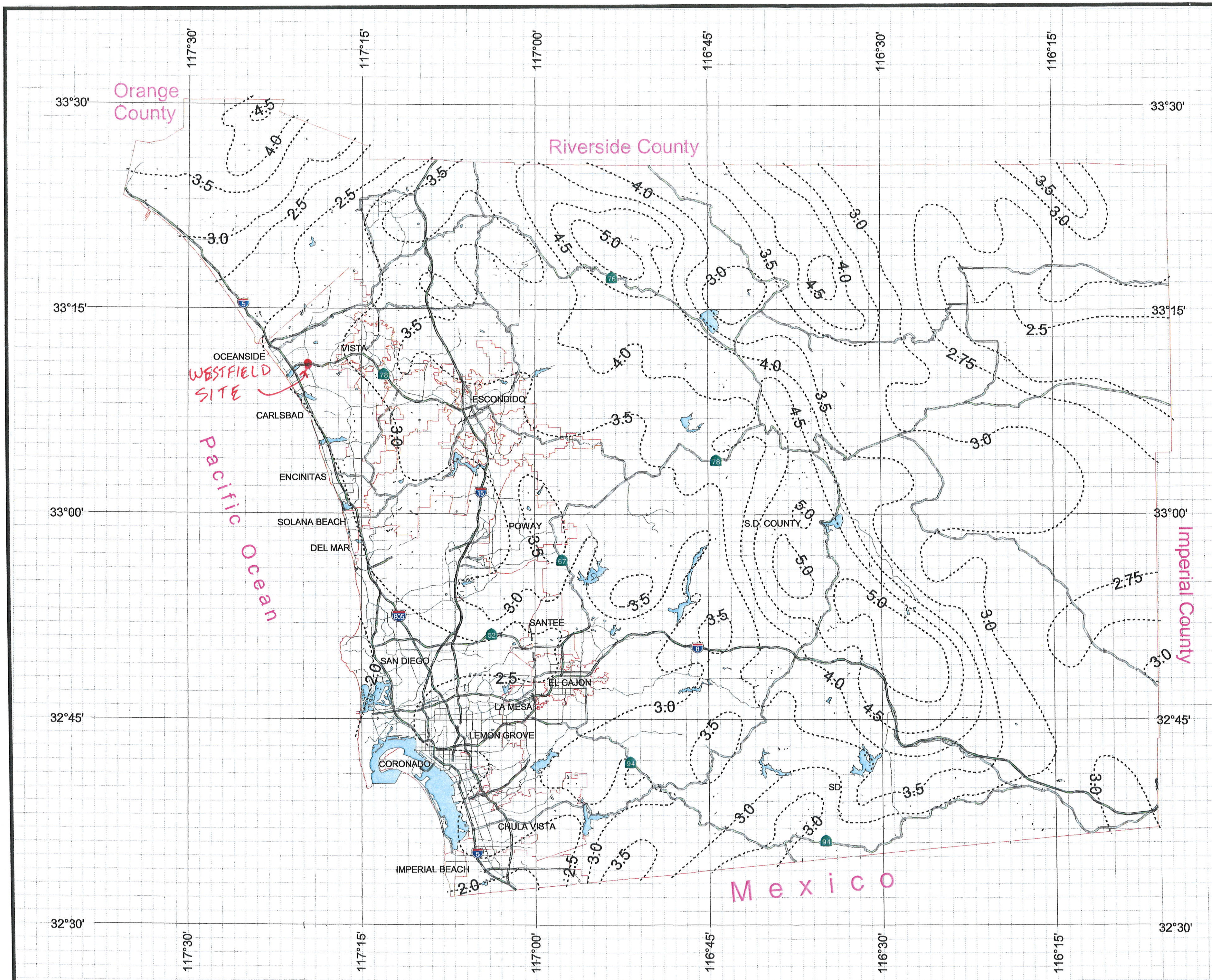
Table 3-1
RUNOFF COEFFICIENTS FOR URBAN AREAS

Land Use		Runoff Coefficient "C"				
			Soil Type			
NRCS Elements	County Elements	% IMPER.	A	B	C	D
Undisturbed Natural Terrain (Natural)	Permanent Open Space	0*	0.20	0.25	0.30	0.35
Low Density Residential (LDR)	Residential, 1.0 DU/A or less	10	0.27	0.32	0.36	0.41
Low Density Residential (LDR)	Residential, 2.0 DU/A or less	20	0.34	0.38	0.42	0.46
Low Density Residential (LDR)	Residential, 2.9 DU/A or less	25	0.38	0.41	0.45	0.49
Medium Density Residential (MDR)	Residential, 4.3 DU/A or less	30	0.41	0.45	0.48	0.52
Medium Density Residential (MDR)	Residential, 7.3 DU/A or less	40	0.48	0.51	0.54	0.57
Medium Density Residential (MDR)	Residential, 10.9 DU/A or less	45	0.52	0.54	0.57	0.60
Medium Density Residential (MDR)	Residential, 14.5 DU/A or less	50	0.55	0.58	0.60	0.63
High Density Residential (HDR)	Residential, 24.0 DU/A or less	65	0.66	0.67	0.69	0.71
High Density Residential (HDR)	Residential, 43.0 DU/A or less	80	0.76	0.77	0.78	0.79
Commercial/Industrial (N. Com)	Neighborhood Commercial	80	0.76	0.77	0.78	0.79
Commercial/Industrial (G. Com)	General Commercial	85	0.80	0.80	0.81	0.82
Commercial/Industrial (O.P. Com)	3 Office Professional/Commercial	90	0.83	0.84	0.84	0.85
Commercial/Industrial (Limited I.)	Limited Industrial	90	0.83	0.84	0.84	0.85
Commercial/Industrial (General I.)	General Industrial	95	0.87	0.87	0.87	0.87

*The values associated with 0% impervious may be used for direct calculation of the runoff coefficient as described in Section 3.1.2 (representing the pervious runoff coefficient, Cp, for the soil type), or for areas that will remain undisturbed in perpetuity. Justification must be given that the area will remain natural forever (e.g., the area is located in Cleveland National Forest).

DU/A = dwelling units per acre

NRCS = National Resources Conservation Service



County of San Diego Hydrology Manual

Rainfall Isopluvials

100 Year Rainfall Event - 6 Hours

Isopluvial (inches) 2.65

DPW GIS
Department of Public Works Geographic Information Services

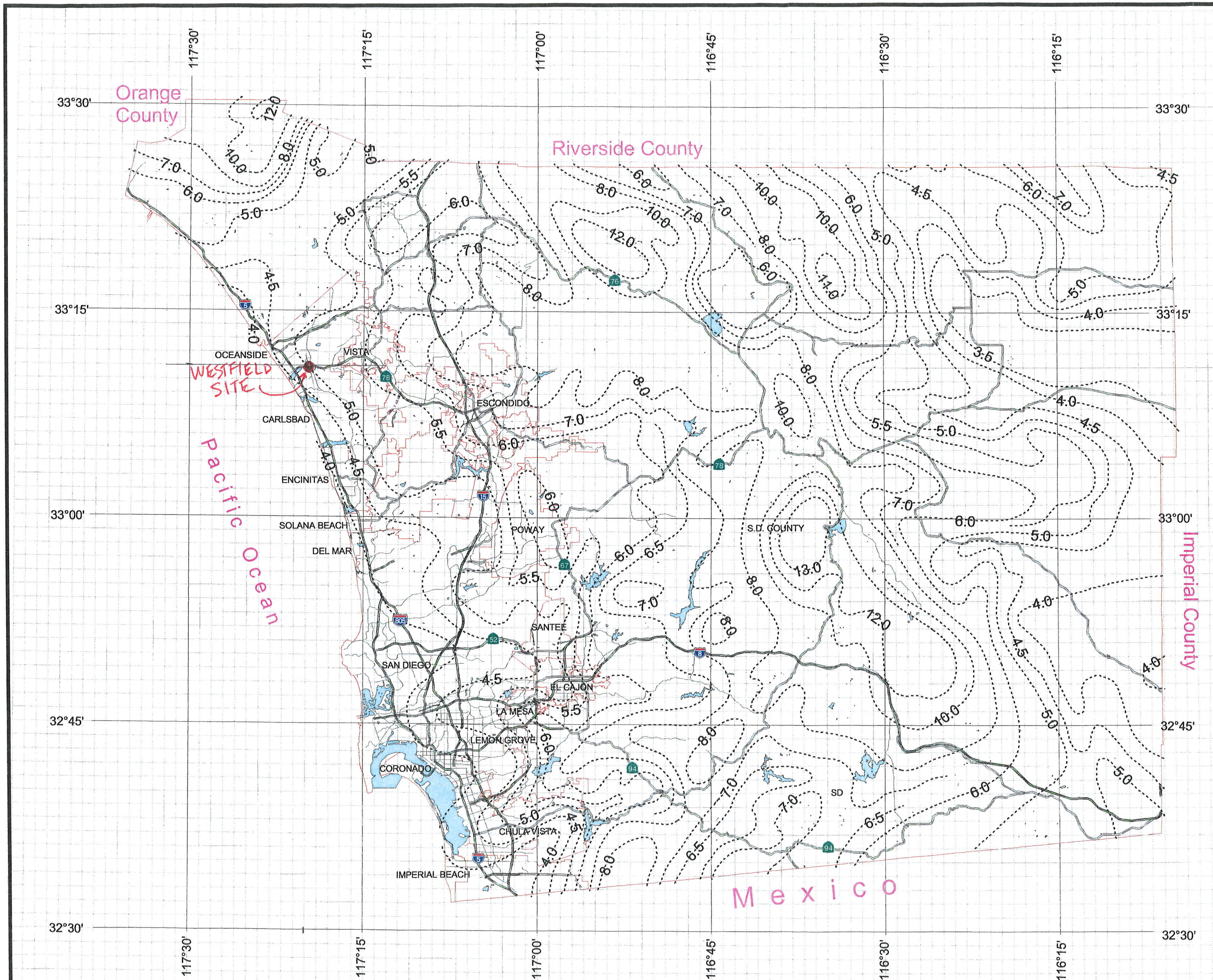
SanGIS
We Have San Diego Covered!

N S E W

3 0 3 Miles

County of San Diego Hydrology Manual

Rainfall Isopluvials



100 Year Rainfall Event - 24 Hours

....	Isopluvial (inches)

5.0

Department of Public Works
Geographic Information Services

We Have San Diego Covered!

N
W
E
S

3 0 3 Miles

SWMP XX-XX
STORM WATER MANAGEMENT PLAN

For

WESTFIELD CARLSBAD
CARLSBAD, CA

EIR 09-02 / SP 09-01 / SDP 09-04

February 20, 2012
Revised July 5, 2012

Prepared By:

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FOR REVIEW ONLY

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Storm Water Standards Questionnaire E-34
2010 303(d) List

ATTACHMENT:
A. BMP Sizing

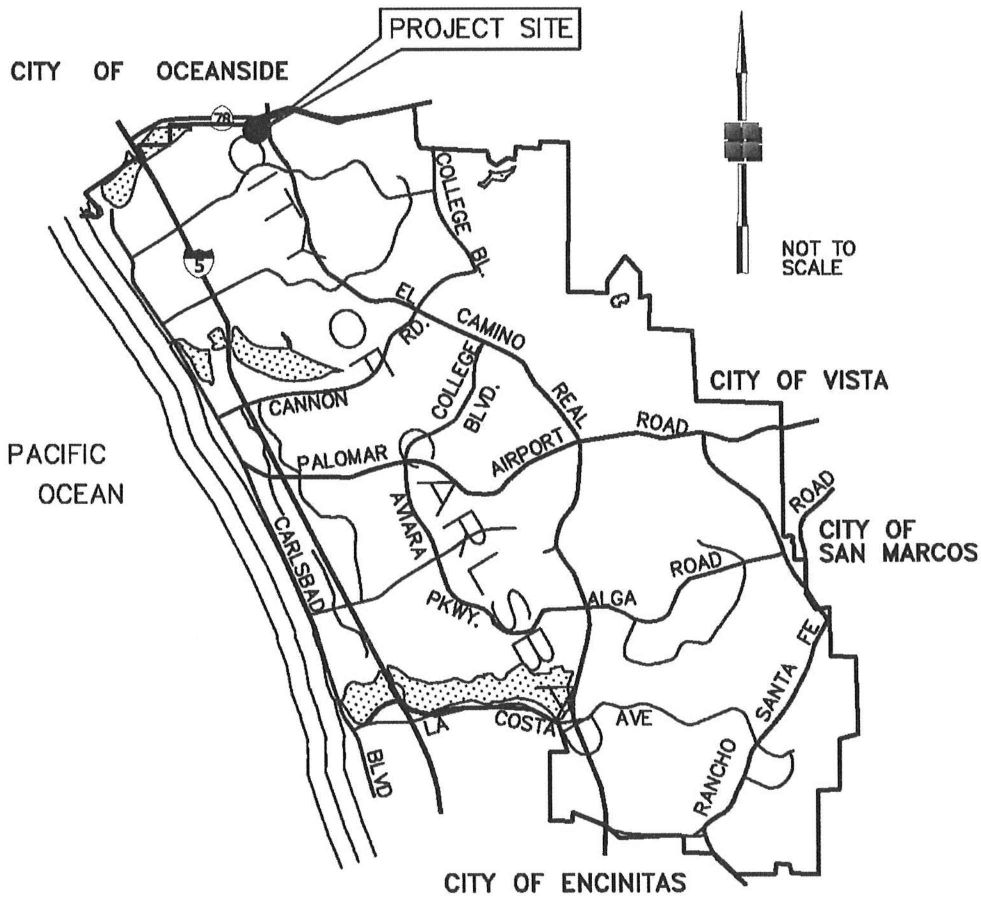
FOR REVIEW ONLY

1.0 INTRODUCTION

Federal, state, and local agencies have established goals and objectives for storm water quality. The proposed project will comply with all federal, state, and local permits including the National Pollutant Discharge Elimination System (NPDES) permit, Order No. R9-2007-0001, NPDES No. CAS0108758 issued to the State Water Resources Control Board (SWRCB) on January 24, 2007. This Storm Water Management Plan (SWMP) addresses water quality requirements associated with the entitlement of the Westfield Carlsbad site development permit (SDP 09-04), which proposes redevelopment of a portion of the existing shopping center, Westfield Plaza Camino Real, located west of El Camino Real and north of Marron Road in the city of Carlsbad (see Vicinity Map). This SWMP is for preliminary engineering and follows the criteria outlined in the City of Carlsbad's January 14, 2011, *Standard Urban Storm Water Management Plan* (SUSMP).

According to the City's Storm Water Standards Questionnaire E-34 (attached following this report text), the project is considered to be "Significant Redevelopment" because it disturbs over 1 acre of land and is a pollutant-generating redevelopment project (the project introduces new impervious surfaces exceeding 5,000 square feet and new landscaping). Consequently, the project meets priority development project requirements. The SUSMP outlines the SWMP objectives, which are to identify site opportunities and constraints, identify pollutants and conditions of concern, follow low impact development design objectives, describe best management practices (BMPs), and outline maintenance requirements. BMPs will be utilized to the maximum extent practicable to provide a long-term solution for addressing runoff water quality. BMPs were selected that meet the current regulations and also fit within the redevelopment project.

2.0 VICINITY MAP



3.0 PROJECT DESCRIPTION

The 80.94 acre Specific Plan site is located at 2525 El Camino Real in Carlsbad, California. The site is bounded by State Highway 78 and Buena Vista Creek to the north, El Camino Real to the east, commercial development to the west, and Marron Road and residential development to the south.

Under current pre-project conditions, the site is a fully developed shopping mall with a comprehensive storm drain system. The central portion of the site contains the enclosed shopping complex, while the perimeter contains the supporting parking lot. The site generally drains away from the central shopping buildings to existing drainage facilities along Marron Road and Buena Vista Creek.

3.1 Narrative of Project Activities

The existing Westfield Carlsbad shopping center is being revitalized. The eastern portion of the main enclosed shopping complex will be re-configured and expanded to accommodate new tenants. As a result, portions of the adjacent parking lot will be reconfigured as well. Areas for future outlying buildings will be set aside in the southeasterly portion of the parking lot. Each outlying building pad area will require a future Site Development Plan (SDP) and may or may not include restaurants. A future SWMP will address the future SDP and restaurant requirements in more detail, such as dock areas, equipment wash areas, and surface parking areas.

Under the expansion, the landscape area within the 18.03 acre project area (limits of work) will increase by over 1.09 acres due to the additional landscape islands in the parking lot. In addition, the project proposes to add over 30,500 square feet of pervious paving in the parking lot. In accordance with the final HMP criteria, since there is a net decrease in impervious area, the project is exempt from hydro-modification requirements. Although exempt from hydro-modification, this project is required to provide post-construction best management practices (treatment control) to filter pollutants from urban runoff.

Specific details of the drainage basins, impervious/pervious areas, and BMP sizing can be found in Attachment A.

3.2 Constraints and Opportunities

The site currently contains a fully-developed shopping mall. Therefore, the drainage patterns, drainage infrastructure, site layout, impervious/pervious areas have been established and provide groundwork for the proposed project. Since the site is mostly impervious, the project can avoid hydromodification requirements by increasing the pervious area. This can be accomplished by increasing the landscape areas and providing pervious pavement in portions of the parking lot. The landscape areas and pervious pavement also provide opportunities to treat the water quality runoff.

4.0 POLLUTANTS AND CONDITIONS OF CONCERN

4.1 Anticipated Pollutants Based on Land Use

The following table lists pollutants of concern that are anticipated or can potentially exist at proposed priority development project sites. The pollutants are from the city of Carlsbad's SUSMP. The project falls within the commercial development, restaurants, parking lots, and streets, highways & freeways categories (rows shaded in the table). All of the listed pollutants are either anticipated or can potentially exist at the developed site.

Table 1. Anticipated and Potential Pollutants Generated by Land Use Type.

	General Pollutant Categories								
Project Categories	Sediments	Nutrients	Heavy Metals	Organic Compounds	Trash & Debris	Oxygen Demanding Substances	Oil & Grease	Bacteria & Viruses	Pesticides
Detached Residential Development	X	X			X	X	X	X	X
Attached Residential Development	X	X			X	P(1)	P(2)	P	X
Commercial Development >100,000 ft²	P(1)	P(1)	X	P(2)	X	P(5)	X	P(3)	P(5)
Automotive Repair	X		X	X	X	X	X		
Restaurants			X	X(4)(5)	X		X		
Hillside Development >5,000 ft²					X	X	X	X	P(1)
Parking Lots	X	X			X	X	X		X
Streets, Highways & Freeways	P(1)	P(1)	X		X	P(1)	X		P(1)

X = anticipated
P = potential
(1) A potential pollutant if landscaping exists on-site.
(2) A potential pollutant if the project includes uncovered parking areas.
(3) A potential pollutant if land use involves food or animal waste products.
(4) Including petroleum hydrocarbons.
(5) Including solvents.

4.2 Receiving Waters Downstream

The project lies within the El Salto Hydrologic Sub Area (904.21) of the Buena Vista Creek Hydrologic Area (904.20) in the Carlsbad Hydrologic Unit (904.00). The total drainage area of the hydrologic unit is approximately 210 square miles. Runoff from the hydrologic area ultimately drains to Buena Vista Creek and the Buena Vista Lagoon. All of the project runoff will enter Buena Vista Creek. The project site represents less than one percent of the Buena Vista Creek watershed.

The beneficial uses for the hydrologic unit are included in Tables 2 and 3. These tables were obtained from the April 25, 2007 amended *Water Quality Control Plan for the San Diego Basin (9).* The following contains definitions of the beneficial uses in the tables:

MUN – Municipal and Domestic Supply: Includes uses of water for community, military, or individual water supply systems including, but not limited to, drinking water supply.

AGR – Agricultural Supply (AGR): Includes uses of water for farming, horticulture, or ranching including, but not limited to, irrigation, stock watering, or support of vegetation for range grazing.

IND – Industrial Services Supply: Includes uses of water for industrial activities that do not depend primarily on water quality including, but not limited to, mining, cooling water supply, hydraulic conveyance, gravel washing, fire protection, or oil well re-pressurization.

REC1 – Contact Recreation: Includes uses of water for recreational activities involving body contact with water, where ingestion of water is reasonably possible. These uses include, but are not limited to, swimming, wading, water-skiing, skin and SCUBA diving, surfing, white water activities, fishing, or use of natural hot springs.

REC2 – Non-Contact Recreation: Includes the uses of water for recreational involving proximity to water, but not normally involving body contact with water, where ingestion of water is reasonably possible. These uses include, but are not limited to, picnicking, sunbathing, hiking, camping, boating, tide pool and marine life study, hunting, sightseeing, or aesthetic enjoyment in conjunction with the above activities.

WARM – Warm Freshwater Habitat: Includes uses of water that support warm water ecosystems including, but not limited to, preservation or enhancement of aquatic habitats, vegetation, fish or wildlife, including invertebrates.

WILD – Wildlife Habitat: Includes uses of water that support terrestrial ecosystems including, but not limited to, preservation and enhancement of terrestrial habitats, vegetation, wildlife, (e.g., mammals, birds, reptiles, amphibians, invertebrates), or wildlife water and food sources.

RARE – Rare: Bodies of water where the protection of a threatened or endangered species depends on the water either directly, or to support its habitat.

Inland surface waters for the Buena Vista Creek Hydrologic Area have the beneficial uses shown in Table 2:

Table 2. Beneficial Uses for Inland Surface Waters

Hydrologic Unit Code	Mun	Agr	Ind	Proc	Gwr	Frsh	Pow	Rec1	Rec2	Biol	Warm	Cold	Wild	Rare	Spwn
904.21	+	•	•					•	•		•		•	•	

\+ Exempted by the Regional Board from the municipal used designation.
• Existing Beneficial Use

Groundwater beneficial uses for the El Salto Hydrologic Subarea are shown in Table 3:

Table 3. Beneficial Uses for Groundwater

Hydrologic Unit Code	Mun	Agr	Ind	Proc	Frsh	Gwr
904.21	•	•	o			

• Existing Beneficial Use
o Potential Beneficial Use

4.3 Carlsbad Watershed Impaired Water Bodies Downstream

According to the 2010 303(d) list approved by the US Environmental Protection Agency (attached after this report text), the receiving waterbody closest to the project vicinity, Buena Vista Creek, is 303(d) listed for sediment toxicity and selenium. Buena Vista Creek empties into Buena Vista Lagoon, which is 303(d) listed for indicator bacteria, nutrients, and sedimentation/siltation. Both Buena Vista Creek and Buena Vista Lagoon are water segments where a total maximum daily load is required, but not yet completed.

4.4 Primary Pollutants of Concern

The primary pollutants of concern are the anticipated and potential pollutants in Table 1 that are also 303(d) listed in the receiving waterbodies. Based on this, the primary pollutants of concern include sediments (or sediment toxicity, sedimentation, and siltation), nutrients, heavy metals (selenium), and bacteria & viruses (indicator bacteria).

5.0 CONDITIONS OF CONCERN

Under pre-project conditions, the site is fully developed with an enclosed indoor shopping complex and surrounding parking. Therefore, the project footprint and surrounding shopping mall area is nearly entirely impervious. The shopping center was constructed well before the current water quality regulations.

As indicated in Section 2.1, the project will cause an increase in pervious areas. Runoff generated within the project footprint will also be subject to the current water quality regulations. Therefore, the project will not cause an increase in flow rates or flow volumes, and will provide treatment for water quality flows. Consequently, the project will not cause a condition of concern.

6.0 LID SITE DESIGN BMPS

The City of Carlsbad's SUSMP includes integrated low impact development (LID) guidelines with four strategies:

1. Optimize the site layout by preserving natural drainage features and designing buildings and circulation to minimize the amount of roofs and paving.

2. Use pervious surfaces such as turf, gravel, or pervious pavement—or use surfaces that retain rainfall. All drainage from these surfaces is considered to be "self-treating".

3. Disperse runoff from impervious surfaces on to adjacent pervious surfaces (e.g., direct a roof downspout to disperse runoff onto a lawn).

4. Drain impervious surfaces to engineered Treatment Control BMP's (TCBMP's) or Integrated Management Practices (IMPs), such as bioretention facilities, planter boxes, cisterns, or dry wells. IMPs infiltrate runoff to groundwater and/or percolate runoff through engineered soil and allow it to drain away slowly.

The project design is in compliance with these strategies. The site layout has been designed to reduce the impervious area through landscape areas and the use of pervious paving. Runoff from the roofs will be disconnected from the underground drainage system and allowed to flow towards pervious landscape areas and paving, where possible. The following sections describe additional implementation of the LID strategies.

6.1 Maintain Pre-Development Runoff Characteristics

6.1.1 Building density has been maximized through a multiple-story design.

6.1.2 The proposed drive aisles and parking lots are the minimum allowed width of 24 feet.

6.1.3 Trees and other vegetation have been incorporated into the proposed parking areas to the maximum extent possible.

6.1.4 Runoff will be treated by vegetated landscape areas within the parking areas.

6.1.5 The roof drains for the proposed re-configured building will be directed into the vegetated landscape areas within the perimeter of the buildings. SDP site plan has indicated roof drain and planter locations.

6.1.6 Trees will be preserved in the parking areas where possible; and proposed vegetation will be drought-tolerant.

6.2 Protect Slopes and Channels

6.2.1 The proposed improvements will not adversely affect Buena Vista Creek.

6.2.2 There are no significant slopes being proposed by the project.

7.0 SOURCE CONTROL BMP's

Table 4 addresses the source control BMPs from Appendix I of the Carlsbad SUSMP.

Table 4. Pollutant Sources and Source Control Checklist

Potential Source of Runoff Pollutants	Permanent Source Control BMPs	Operational Source Control BMPs
On-site storm drain inlets	Mark all inlets with "No Dumping – I live downstream"	• Maintain and periodically repaint inlet markings • Provide stormwater pollution information to owners, lessees, and operators (Fact sheet SC-44 from the CASQA Stormwater Quality Handbook

		at www.cabmphandbooks.com) • Owner/lessee agreements shall state "Tenant shall not allow anyone to discharge anything to storm drains or to store or deposit materials so as to create a potential discharge to storm drains.
Food service	Restaurants and food service in the revitalization area shall designate an indoor cleaning area.	
Refuse Areas	Refuse is to be collected at least weekly by a refuse removal company. Signs shall be posted on or near dumpsters with the words "Do not dump hazardous materials here" or similar.	An adequate number of receptacles shall be provided. Receptacles shall be inspected regularly and kept covered. Prohibit/prevent dumping of liquid or hazardous wastes. Post "no hazardous materials" signs. Inspect and pick up litter daily and clean up spills immediately. Keep spill control materials on-site. See Fact sheet SC-34, "Waste Handling and Disposal" in the CASQA Stormwater Quality Handbook at www.cabmphandbooks.com.
Need for future indoor & structural pest control	Buildings shall be designed to avoid openings that would encourage entry of pests.	Integrated Pest Management (e.g., the EPA's *Citizen's Guide to Pest Control and Pesticide Safety)* information shall be provided to owners, lessees, and operators.

Landscape/Outdoor Pesticide Use	Final landscape plans will accomplish all of the following. • Preserve existing native trees, shrubs, and ground cover to the maximum extent possible. • Design landscaping to minimize irrigation and runoff, to promote surface infiltration where appropriate, and to minimize the use of fertilizers and pesticides that can contribute to stormwater pollution. • Where landscaped areas can retain or detain stormwater, specify plants that are tolerant of saturated soil conditions. • Consider using pest-resistant plants, especially adjacent to hardscape. • To ensure successful establishment, select plants appropriate to site soils, slopes, climate, sun, wind, rain, land use, air movement, ecological consistency, and plant interactions	Maintain landscaping using minimum or no pesticides. See applicable operational BMPs in Fact Sheet SC-41, "Building and Grounds Maintenance," and TC-30, "Vegetated Swale," in the CASQA Stormwater Quality Handbooks at www.cabmphandbooks.com Integrated Pest Management (e.g., the EPA's *Citizen's Guide to Pest Control and Pesticide Safety)* information shall be provided to owners, lessees, and operators.
Vehicle and equipment cleaning	The shopping center will prohibit car washing at the site. The shopping mall manager will be responsible for enforcing this requirement.	
Vehicle/Equipment Repair and Maintenance	The shopping center will prohibit repair and maintenance activities in areas exposed to	

	precipitation and storm flows. The shopping mall manager will be responsible for enforcing this requirement.	
Roofing, Gutters, and Trim	The architectural design will avoid roofing, gutters, and trim made of copper or other unprotected metals that may leach into runoff.	
Loading Docks	The proposed loading areas are not covered. They are designed to slope away from the driveways and towards the back. There will be trench drains at the back of the loading area. FloGard LoPro Trench Drain Filter inserts will be installed to provide treatment BMP. FloGard LoPro Trench Drain Filter specs are attached for reference.	Move loaded and unloaded items indoors as soon as possible. See Fact Sheet SC-30, "Outdoor Loading and Unloading" in the CASQA Stormwater Quality Handbooks at www.cabmphandbooks.com
Fire Sprinkler Test Water	Provide a means to drain fire sprinkler test water to the sanitary sewer.	See Fact Sheet SC-41, "Building and Grounds Maintenance" in the CASQA Stormwater Quality Handbooks at www.cabmphandbooks.com
Miscellaneous Drain or Wash Water	• Boiler drain lines shall be directly or indirectly connected to the sanitary sewer system and may not discharge to the storm drain system. • Condensate drain lines may discharge to landscaped areas if the flow is small enough that runoff will not occur. Condensate lines may not discharge to the storm drain system. • Rooftop mounted equipment with potential to produce pollutants shall be roofed and/or have	

	secondary containment. • Any roofing, gutters, and trim made of copper or other unprotected metals that may leach into runoff.	
Plazas, sidewalks, and parking lots.		Plazas, sidewalks, and parking lots shall be swept regularly to prevent the accumulation of litter and debris. Debris from pressure washing shall be collected to prevent entry into the storm drain system. Wash water containing any cleaning agent or degreaser shall be collected and discharged to the sanitary sewer and not discharged to a storm drain.

7.1 Design Outdoor Trash Storage Areas to Reduce Pollution Introduction

Proposed trash storage areas are to be paved with impervious concrete, sloped to not allow run-off from adjoining areas, and walled and gated to prevent unauthorized access, off-site transport of trash, and contain a roof or awning to minimize direct precipitation. The individual containers will have attached lids that exclude rain to minimize direct precipitation.

7.2 Efficient Irrigation Systems & Landscape Design

7.2.1 Rain shutoff devices shall be employed to prevent irrigation during precipitation consistent with the Carlsbad Landscape Manual and specified in the project's landscape plans.

7.2.2 Irrigation systems will be designed to each landscape area's specific water requirements consistent with the Carlsbad Landscape Manual and specified in the project's landscape plans.

7.2.3 Shutoff valves shall be installed on the irrigation system. These valves are triggered by a pressure drop to control water loss in the event of a broken sprinkler head.

7.3 Provide Storm Water System Stenciling and Signage

The design proposes permanent marking of all storm water conveyance system inlets and catch basins within the project area with prohibitive language (e.g., "No Dumping – I Live Downstream"), satisfactory to the City Engineer.

8.0 BMP APPLICABLE TO INDIVIDUAL PRIORITY PROJECT CATEGORIES

This project is subject to Priority Project Requirements.

8.1 Surface Parking and Private Roads

All proposed impervious driveways are tilted not crowned and runoff will sheet flow across into vegetated swales around the perimeter of the project.

8.2 Loading Areas

Loading areas will not be covered. But it is designed to slope away from the driveways and towards the back. There will be trench drains at the back of the loading area. FloGard LoPro Trench Drain Filter inserts will be installed to provide treatment BMP. FloGard LoPro Trench Drain Filter specs are attached for reference.

8.3 Vehicle & Equipment Wash Areas

Restaurant equipment wash areas shall be covered and linked to the sewer system.

9.0 STRUCTURAL TREATMENT CONTROL BMP's

9.1 Selection Procedure

The pollutants of concern outlined in Section 4.4 include sediments, nutrients, heavy metals, and bacteria & viruses. Although sediments qualify as a pollutant of concern, the site will not generate much sediment since it will be mostly impervious and the pervious areas will be landscaped. The pollutants of concern as classified by the SUSMP as "pollutants that tend to associate with fine particles during treatment." Bioretention facilities and infiltration facilities have a high effectiveness for treatment of these types of pollutants. Vegetated swales have a medium effectiveness for treatment of these types of pollutants. The BMPs selected for the site will be a combination of infiltration facilities and vegetated swales. Trench drain filter inserts will also be installed at the loading area.

The implementation of these BMP is selected to fit within the site layout. Each BMP is discussed below.

9.2 Vegetated Strips

Majority of the on-site runoff will be conveyed through vegetated swales prior to entering the public storm drain system. The 10' wide vegetated swales will be installed along the southerly (along Marron Road) and easterly (along El Camino Real) site perimeters. Runoff from the majority of the project footprint flows to these areas, so vegetated swales are well-suited to the proposed layout. The 5' wide vegetated swales will be installed in the parking lot on the north side of the buildings. Storm runoff from the disturbed areas on the north side will be captured in the proposed ribbon gutter system, and be directed into the proposed vegetated swale. The SUSMP states that projects not subject to hydromodification and not using the unified LID approach can use the numeric sizing approach for treatment control. This involves sizing vegetated swales using the flow-based approach, which is based on the rational method equation with an intensity of 0.2 inches per hour. Flow based sizing calculations for the vegetated swales are included in Attachment A. It is necessary to obtain geotechnical recommendations during final design regarding soil conditions.

9.3 Porous Pavement

Porous pavement will be included in the southerly and easterly perimeter of the project's parking area. The porous pavement will infiltrate a portion of the surface runoff before it enters the vegetated swales. It is necessary to obtain geotechnical recommendations during final design regarding soil conditions.

9.4 Trench Drain Filter Inserts

Because the proposed loading areas are not covered, runoff from the loading areas will be directed to the proposed trench drains at the back of the loading area. FloGard LoPro Trench Drain Filters will be installed in the trench drain to treat runoff from loading area before it is discharged into the storm drain system. FloGard LoPro Trench Drain Filter specs are attached for reference.

10.0 BMP MAINTENANCE PROVISIONS

The developer will be responsible for funding and implementing the operations and maintenance of the project BMPs. Provisions will be made to transfer operations and maintenance to the new owner in the event of a change in ownership. The shopping center will ultimately be responsible for ongoing operations and maintenance. The following describes the specific BMP maintenance.

Porous Pavement

After installation, inspect pavement once a month for 4 to 6 months. After this period inspection can occur annually, particularly after there has been heavy rain or storms, for this is the time when the drainage voids can become clogged with organic debris. Sweep and/or vacuum the permeable surface every 3 months. Street sweepers that have a vacuum and brushes can be used. High pressure hosing shall be performed after sweeping/vacuuming. Voids should be kept filled with aggregate. Replace damaged pavement, as needed.

Landscaping and Vegetated Swales

Maintenance will be performed by landscaping personnel. The vegetation will be maintained and inspected on a monthly basis or more frequently, if needed, by landscape maintenance staff and will be replaced or replanted, as necessary, to maintain a dense, healthy cover. The vegetation will also be inspected after major storm events. Maintenance shall include periodic mowing, weed control, irrigation, reseeding/replanting of bare areas, and clearing of debris. A design grass height of 6 inches is recommended. Grass clippings shall not be left in grass swales. The private drainage system will shall be kept clear of debris and inspect prior to and during the rainy season to ensure it is free-flowing.

Trench Drain Filter Inserts

Maintenance requirement of the FloGard LoPro Trench Drain Filter is provided by manufacturer. It is attached in this report for reference.

Efficient Irrigation

The landscaping personnel shall inspect and maintain the irrigation system on a regular basis. This will occur during the routine maintenance activities. All valves, heads, shutoff devices, lines, etc. shall be kept in a properly functioning condition. Any defective parts shall be replaced immediately. The irrigation system shall be adjusted to prevent excessive runoff from landscape areas. The irrigation schedule shall be adjusted based on seasonal needs.

Inlet Stenciling

Any stenciling shall be inspected at the beginning and end of each rainy season and repaired or replaced, as needed.

Hazardous Wastes

Suspected hazardous wastes will be analyzed to determine disposal options. Hazardous materials are not expected to be generated on-site; however, if discovered, hazardous materials will be handled and disposed of according to local, state, and federal regulations. A solid or liquid waste is considered a hazardous waste if it exceeds the criteria listed in the California Code of Federal Regulations, Title 22, Article 11 (State of California, 1985).

Maintenance Personnel
Contact: Christopher Holman, Assistant General Manager
Westfield Plaza Camino Real, 2525 El Camino Real Suite 100, Carlsbad, CA 92008
Phone: (760) 729-6183
E-mail: Cfholman@westfield.com

11.0 CERTIFICATIONS

Preparer Certification

The selection, sizing, and preliminary design of stormwater treatment control measures in this plan meet the requirements of Regional Water Quality Control Board Order R9-2007-0001 and subsequent amendments.

07/05/2012

Haixin Li, PE — Date

Owner Certification

I certify that as owner of the property described herein, I have read and understand the requirements of this Storm Water Management Plan (SWMP) and that I am responsible for ensuring that all stormwater treatment measures described within said SWMP will be properly implemented, monitored, and maintained.

I will execute necessary agreements for BMP maintenance. I will be responsible for operation and maintenance of BMP facilities until that responsibility is formally transferred.

Date

ATTACHMENT A
BMP SIZING

SUMMARY

The best management practices (BMPs) selected for the site will be a combination of, vegetated swales, infiltration facilities (porous pavement), and trench drain filter inserts. (See attached Drainage Management Areas exhibit). This section contains preliminary sizing information for these facilities.

Portions of the on-site runoff will be conveyed through vegetated swales prior to entering the public storm drain system. The 10' wide vegetated swales will be installed along the southerly (along Marron Road) and easterly (along El Camino Real) site perimeters. Runoff from the majority of the project footprint flows to these areas, so vegetated swales are well-suited to the proposed layout. Two 5' wide vegetated swale will be installed in the parking lot on the north side of the shopping complex. The SUSMP states that projects not subject to hydromodification and not using the unified LID approach can use the numeric sizing approach for treatment control. This involves sizing vegetated swales using the flow-based approach, which is based on the rational method equation and determined by multiplying the runoff coefficient, rainfall intensity (0.2 inches per hour for water quality), and tributary area, or:

$Q=CIA$ where Q is the water quality flow rate, cfs
C is the runoff coefficient = 0.85 for type D soil and 90% impervious (the site contains type C and D soil. Type D was selected to be conservative).
I is the rainfall intensity = 0.2 inches per hour
A is the tributary area (see the DMA exhibit)

The rational method results are as follows for the 10' wide bio-swale:

Tributary Area[1], ac	C	Intensity, in/hr	Flow Rate, cfs
3.47	0.85	0.2	0.59
2.77	0.85	0.2	0.47
4.75	0.85	0.2	0.81
2.50	0.85	0.2	0.43
1.26	0.85	0.2	0.21
3.79	0.85	0.2	0.64

[1]See DMA exhibit for location of tributary areas.

Summary of Water Quality Flow Rates Tributary to 10' Vegetated Swales

The vegetated swale sizing requirements are determined from the tabulated flow rates and the CASQA guidelines (see attached TC-30 data sheet). CASQA states that vegetated swales should be analyzed with a Manning's n of 0.25, side slopes no steeper than 3:1, a channel slope less than 2.5 percent, a bottom width of less than 10 feet, and a minimum hydraulic residence time of 10 minutes. Each swale serving the above tributary areas was analyzed using the FlowMaster program. The calculations are attached and summarized in the table below. The swales were assumed to have n=0.25, 3:1 side slopes, a 6-foot bottom width, and a longitudinal slope based on the existing topography. The minimum required swale lengths were determined by multiplying the flow velocity by 10 minutes and applying the required conversion factor (60 seconds per minute).

Tributary Area, ac	Slope, ft/ft	Normal Depth, ft	Flow Velocity, fps	Minimum Swale Length, ft	Length on Site Plan, ft
3.47	0.0153	0.29	0.30	180	470
2.77	0.0167	0.25	0.28	168	290
4.75	0.0109	0.38	0.29	174	270
2.50	0.0189	0.23	0.28	168	120
1.26	0.0292	0.13	0.25	150	260
3.79	0.0158	0.30	0.31	186	310

The rational method results are as follows for the 5' wide bio-swales:

Tributary Area[1], ac	C	Intensity, in/hr	Flow Rate, cfs
0.88	0.85	0.2	0.15
0.88	0.85	0.2	0.15

[1]See DMA exhibit for location of tributary areas.

Summary of Water Quality Flow Rates Tributary to 5' Vegetated Swales

The calculations are attached and summarized in the table below. The swales were assumed to have n=0.25, 3:1 side slopes, a 2-foot bottom width, and a longitudinal slope based on the existing topography.

Tributary Area, ac	Slope, ft/ft	Normal Depth, ft	Flow Velocity, fps	Minimum Swale Length, ft	Length on Site Plan, ft
0.88	0.021	0.22	0.26	156	130
0.88	0.024	0.21	0.28	168	160

Summary of Vegetated Swale Analyses

All of the vegetated swales shown on the site plan exceed or are very close to the minimum required length except for the swale serving the 2.50 acre area. During final engineering, some of the swales could be extended to achieve the needed length, or the cross-section geometry or slope could be adjusted to meet the treatment requirement.

The above results show that vegetated swales are feasible BMPs to treat runoff from the southerly, easterly and northerly portions of the site. The calculations show that the vegetated swales are sufficient to treat on-site runoff. Assumptions were made for the roof drainage, which may vary during final engineering. In addition, the calculations do not include the benefits from the porous pavement, which can be accounted for during final engineering.

CITY OF CARLSBAD

STORM WATER STANDARDS QUESTIONNAIRE E-34

Development Services
Land Development Engineering
1635 Faraday Avenue
760-602-2750
www.carlsbadca.gov

INSTRUCTIONS:

To address post-development pollutants that may be generated from development projects, the City requires that new development and significant redevelopment priority projects incorporate Permanent Storm Water Best Management Practices (BMP's) into the project design per the City's Standard Urban Stormwater Management Plan (SUSMP). To view the SUSMP, refer to the Engineering Standards (Volume 4, Chapter 2) at www.carlsbadca.gov/standards.

Initially this questionnaire must be completed by the applicant in advance of submitting for a development application (subdivision, discretionary permits and/or construction permits). The results of the questionnaire determine the level of storm water standards that must be applied to a proposed development or redevelopment project. Depending on the outcome, your project will either be subject to 'Standard Stormwater Requirements' or be subject to additional criteria called 'Priority Development Project Requirements'. Many aspects of project site design are dependent upon the storm water standards applied to a project.

Your responses to the questionnaire represent an initial assessment of the proposed project conditions and impacts. City staff has responsibility for making the final assessment after submission of the development application. If staff determines that the questionnaire was incorrectly filled out and is subject to more stringent storm water standards than initially assessed by you, this will result in the return of the development application as incomplete. In this case, please make the changes to the questionnaire and resubmit to the City.

If you are unsure about the meaning of a question or need help in determining how to respond to one or more of the questions, please seek assistance from Land Development Engineering staff.

A separate completed and signed questionnaire must be submitted for each new development application submission. Only one completed and signed questionnaire is required when multiple development applications for the same project are submitted concurrently. In addition to this questionnaire, you must also complete, sign and submit a Project Threat Assessment Form with construction permits for the project.

Please start by completing Section 1 and follow the instructions. When completed, sign the form at the end and submit this with your application to the city.

SECTION 1 NEW DEVELOPMENT

Does your project meet one or more of the following criteria:	YES	NO
1. ***Housing subdivisions of 10 or more dwelling units***. Examples: single family homes, multi-family homes, condominium and apartments		X
2. ***Commercial – greater than 1-acre.*** Any development other than heavy industry or residential. Examples: hospitals; laboratories and other medical facilities; educational institutions; recreational facilities; municipal facilities; commercial nurseries; multi-apartment buildings; car wash facilities; mini-malls and other business complexes; shopping malls; hotels; office buildings; public warehouses; automotive dealerships; airfields; and other light industrial facilities.		X
3. ***Heavy Industrial / Industry- greater than 1 acre.*** Examples: manufacturing plants, food processing plants, metal working facilities, printing plants, and fleet storage areas (bus, truck, etc.).		X
4. ***Automotive repair shop.*** A facility categorized in any one of Standard Industrial Classification (SIC) codes 5013, 5014, 5541, 7532-7534, and 7536-7539		X
5. ***Restaurants.*** Any facility that sells prepared foods and drinks for consumption, including stationary lunch counters and refreshment stands selling prepared foods and drinks for immediate consumption (SIC code 5812), where the land area for development is greater than 5,000 square feet. Restaurants where land development is less than 5,000 square feet shall meet all SUSMP requirements except for structural treatment BMP and numeric sizing criteria requirements and hydromodification requirements.		X

6. ***Hillside development.*** Any development that creates more than 5,000 square feet of impervious surface and is located in an area with known erosive soil conditions, where the development will grade on any natural slope that is twenty-five percent (25%) or greater.		X
7. ***Environmentally Sensitive Area (ESA)***[1]. All development located within or directly adjacent[2] to or discharging directly[3] to an ESA (where discharges from the development or redevelopment will enter receiving waters within the ESA), which either creates 2,500 square feet or more of impervious surface on a proposed project site or increases the area of imperviousness of a proposed project site 10% or more of its naturally occurring condition.		X
8. ***Parking lot***. Area of 5,000 square feet or more, or with 15 or more parking spaces, and potentially exposed to urban runoff		X
9. ***Streets, roads, highways, and freeways***. Any paved surface that is 5,000 square feet or greater used for the transportation of automobiles, trucks, motorcycles, and other vehicles		X
10. ***Retail Gasoline Outlets.*** Serving more than 100 vehicles per day and greater than 5,000 square feet		X
11. ***Coastal Development Zone.*** Any project located within 200 feet of the Pacific Ocean and (1) creates more than 2500 square feet of impervious surface or (2) increases impervious surface on property by more than 10%.		X
12. ***More than 1-acre of disturbance.*** Project results in the disturbance of 1-acre or more of land and is considered a Pollutant-generating Development Project[4].		X

1 Environmentally Sensitive Areas include but are not limited to all Clean Water Act Section 303(d) impaired water bodies; areas designated as Areas of Special Biological Significance by the State Water Resources Control Board (Water Quality Control Plan for the San Diego Basin (1994) and amendments); water bodies designated with the RARE beneficial use by the State Water Resources Control Board (Water Quality Control Plan for the San Diego Basin (1994) and amendments); areas designated as preserves or their equivalent under the Multi Species Conservation Program within the Cities and County of San Diego; and any other equivalent environmentally sensitive areas which have been identified by the Copermittees.

2 "Directly adjacent" means situated within 200 feet of the Environmentally Sensitive Area.

3 "Discharging directly to" means outflow from a drainage conveyance system that is composed entirely of flows from the subject development or redevelopment site, and not commingled with flow from adjacent lands.

4 Pollutant-generating Development Projects are those projects that generate pollutants at levels greater than background levels. In general, these include all projects that contribute to an exceedance to an impaired water body or which create new impervious surfaces greater than 5000 square feet and/or introduce new landscaping areas that require routine use of fertilizers and pesticides. In most cases linear pathway projects that are for infrequent vehicle use, such as emergency or maintenance access, or for pedestrian or bicycle use, are not considered Pollutant-generating Development Projects if they are built with pervious surfaces or if they sheet flow to surrounding pervious surfaces.

INSTRUCTIONS:

Section 1 Results:

If you answered **YES** to **ANY** of the questions above, your project is subject to **Priority Development Project** requirements. Skip Section 2 and please proceed to Section 3. Check the "meets PRIORITY DEVELOPMENT PROJECT requirements" box in Section 3. Additional storm water requirements will apply per the SUSMP.

If you answered **NO** to **ALL** of the questions above, then please proceed to Section 2 and follow the instructions.

CITY OF CARLSBAD

STORM WATER STANDARDS QUESTIONNAIRE E-34

Development Services
Land Development Engineering
1635 Faraday Avenue
760-602-2750
www.carlsbadca.gov

SECTION 2	SIGNIFICANT REDEVELOPMENT	
INSTRUCTIONS: Complete the questions below regarding your project	**YES**	**NO**
1. Project results in the disturbance of 1-acre or more of land and is considered a Pollutant-generating Development Project *?	X	
INSTRUCTIONS: If you answered **NO**, please proceed to question 2. If you answered **YES**, then you **ARE** a significant redevelopment and you **ARE** subject to **PRIORITY DEVELOPMENT PROJECT** requirements. Please check the "meets PRIORITY DEVELOPMENT PROJECT requirements" box in Section 3 below.		
2. Is the project redeveloping an existing priority project type? (Priority projects are defined in Section 1)		
INSTRUCTIONS: If you answered **YES**, please proceed to question 3. If you answered **NO**, then you **ARE NOT a** significant redevelopment and your project is subject to **STANDARD STORMWATER REQUIREMENTS**. Please check the "does not meet PDP requirements" box in Section 3 below.		
3. Is the work limited to trenching and resurfacing associated with utility work; resurfacing and reconfiguring surface parking lots and existing roadways; new sidewalk; bike lane on existing road and/or routine maintenance of damaged pavement such as pothole repair? Resurfacing/reconfiguring parking lots is where the work does not expose underlying soil during construction.		
INSTRUCTIONS: If you answered **NO**, then proceed to question 4. If you answered **YES,** then you **ARE NOT** a significant redevelopment and your project is subject to **STANDARD STORMWATER REQUIREMENTS**. Please check the "does not meet PDP requirements" box in Section 3 below.		
4. Will your redevelopment project create, replace, or add at least 5,000 square feet of impervious surfaces on existing developed property **or** will your project be located within 200 feet of the Pacific Ocean and (1) create 2500 square feet or more of impervious surface or (2) increases impervious surface on the property by more than 10%? Replacement of existing impervious surfaces includes any activity that is not part of routine maintenance where impervious material(s) are removed, exposing underlying soil during construction.		
INSTRUCTIONS: If you answered **YES**, you **ARE** a significant redevelopment, and you **ARE** subject to **PRIORITY DEVELOPMENT PROJECT** requirements. Please check the "meets PRIORITY DEVELOPMENT PROJECT requirements" box in Section 3 below. Review SUSMP to find out if SUSMP requirements apply to your project envelope or the entire project site. If you answered **NO**, then you **ARE NOT a** significant redevelopment and your project is subject to **STANDARD STORMWATER REQUIREMENTS**. Please check the "does not meet PDP requirements" box in Section 3 below.		

*for definition see Footnote 4 on page 2

SECTION 3 QUESTIONNAIRE RESULTS

☒ My project meets **PRIORITY DEVELOPMENT PROJECT (PDP)** requirements and must comply with additional stormwater criteria per the SUSMP and I understand I must prepare a Storm Water Management Plan for submittal at time of application. I understand flow control (hydromodification) requirements may apply to my project. Refer to SUSMP for details.

☐ My project **does not meet PDP** requirements and must only comply with **STANDARD STORMWATER REQUIREMENTS** per the SUSMP. As part of these requirements, I will incorporate low impact development strategies throughout my project.

Applicant Information and Signature Box

Address: 2525 El Camino Real #100, Carlsbad, CA 92008	Assessor's Parcel Number(s): 156-302-08, -09, -24
Applicant Name: Wayne W. Chang	Applicant Title: Principal
Applicant Signature:	Date: February 20, 2011

This Box for City Use Only

City Concurrence:	YES	NO
By:		
Date:		
Project ID:		

REGION	WATER BODY NAME	WATER TYPE	WATERSHED* CALWATER / USGS HUC	• POLLUTANT ◦ POTENTIAL SOURCES *Relevant Notes*	ESTIMATED AREA ASSESSED	FIRST YEAR LISTED	TMDL REQUIREMENT STATUS**	DATE***
				• Perchlorate ◦ Source Unknown	125 Acres	2010	5A	2019
				• Total Nitrogen as N ◦ Natural Sources ◦ Unknown Nonpoint Source ◦ Urban Runoff/Storm Sewers	125 Acres	2010	5A	2019
				• pH ◦ Source Unknown	125 Acres	2006	5A	2019
9	Buena Creek	River & Stream	90432000 / 18070303	• DDT (Dichlorodiphenyltrichloroethane) ◦ Source Unknown	4.8 Miles	2006	5A	2019
				• Nitrate and Nitrite ◦ Source Unknown	4.8 Miles	2006	5A	2019
9	Buena Vista Creek	River & Stream	90421000 / 18070303	• Sediment Toxicity ◦ Unknown Nonpoint Source ◦ Unknown Point Source	11 Miles	2006	5A	2019
				• Selenium ◦ Source Unknown	11 Miles	2010	5A	2019
9	Buena Vista Lagoon	Estuary	90421000 / 18070303	• Indicator Bacteria ◦ Nonpoint Source ◦ Point Source	202 Acres	1996	5A	2008
				• Nutrients ◦ Nonpoint Source ◦ Point Source *Estimated size of impairment is 150 acres located in upper portion of lagoon.*	202 Acres	1996	5A	2019
				• Sedimentation/Siltation				

REGION	WATER BODY NAME	WATER TYPE	WATERSHED* CALWATER / USGS HUC	• POLLUTANT ◦ POTENTIAL SOURCES *Relevant Notes*	ESTIMATED AREA ASSESSED	FIRST YEAR LISTED	TMDL REQUIREMENT STATUS**	DATE***
				◦ Nonpoint Source ◦ Point Source	202 Acres	1996	5A	2019
9	Chollas Creek	River & Stream	90822000 / 18070304	• Copper ◦ Nonpoint Source ◦ Point Source	3.5 Miles	1996	5A	2004
				• Diazinon ◦ Nonpoint Source ◦ Point Source	3.5 Miles	2002	5B	2003
				• Indicator Bacteria ◦ Nonpoint Source ◦ Point Source ◦ Urban Runoff/Storm Sewers	3.5 Miles	2002	5A	2005
				• Lead ◦ Atmospheric Deposition ◦ Landfills ◦ Nonpoint Source ◦ Point Source ◦ Surface Runoff ◦ Urban Runoff/Storm Sewers	3.5 Miles	1996	5A	2004
				• Phosphorus ◦ Source Unknown	3.5 Miles	2010	5A	2019
				• Total Nitrogen as N ◦ Source Unknown	3.5 Miles	2010	5A	2019
				• Trash ◦ Illegal dumping ◦ Surface Runoff ◦ Urban Runoff/Storm Sewers	3.5 Miles	2010	5A	2021
				• Zinc ◦ Atmospheric Deposition ◦ Highway/Road/Bridge Runoff	3.5 Miles	1996	5A	2004

ATTACHMENT A
BMP SIZING

SUMMARY

The best management practices (BMPs) selected for the site will be a combination of, vegetated swales, infiltration facilities (porous pavement), and trench drain filter inserts. (see attached Drainage Management Areas exhibit). This section contains preliminary sizing information for these facilities.

Portions of the on-site runoff will be conveyed through vegetated swales prior to entering the public storm drain system. The 10' wide vegetated swales will be installed along the southerly (along Marron Road) and easterly (along El Camino Real) site perimeters. Runoff from the majority of the project footprint flows to these areas, so vegetated swales are well-suited to the proposed layout. Two 5' wide vegetated swale will be installed in the parking lot on the north side of the shopping complex. The SUSMP states that projects not subject to hydromodification and not using the unified LID approach can use the numeric sizing approach for treatment control. This involves sizing vegetated swales using the flow-based approach, which is based on the rational method equation and determined by multiplying the runoff coefficient, rainfall intensity (0.2 inches per hour for water quality), and tributary area, or:

Q=CIA where Q is the water quality flow rate, cfs
C is the runoff coefficient = 0.85 for type D soil and 90% impervious (the site contains type C and D soil. Type D was selected to be conservative).
I is the rainfall intensity = 0.2 inches per hour
A is the tributary area (see the DMA exhibit)

The rational method results are as follows for the 10' wide bio-swale:

Tributary Area[1], ac	C	Intensity, in/hr	Flow Rate, cfs
3.47	0.85	0.2	0.59
2.77	0.85	0.2	0.47
4.75	0.85	0.2	0.81
2.50	0.85	0.2	0.43
1.26	0.85	0.2	0.21
3.79	0.85	0.2	0.64

[1]See DMA exhibit for location of tributary areas.

Summary of Water Quality Flow Rates Tributary to 10' Vegetated Swales

The vegetated swale sizing requirements are determined from the tabulated flow rates and the CASQA guidelines (see attached TC-30 data sheet). CASQA states that vegetated swales should be analyzed with a Manning's n of 0.25, side slopes no steeper than 3:1, a channel slope less than 2.5 percent, a bottom width of less than 10 feet, and a minimum hydraulic residence time of 10 minutes. Each swale serving the above tributary areas was analyzed using the FlowMaster program. The calculations are attached and summarized in the table below. The swales were assumed to have n=0.25, 3:1 side slopes, a 6-foot bottom width, and a longitudinal slope based on the existing topography. The minimum required swale lengths were determined by multiplying the flow velocity by 10 minutes and applying the required conversion factor (60 seconds per minute).

Tributary Area, ac	Slope, ft/ft	Normal Depth, ft	Flow Velocity, fps	Minimum Swale Length, ft	Length on Site Plan, ft
3.47	0.0153	0.29	0.30	180	470
2.77	0.0167	0.25	0.28	168	290
4.75	0.0109	0.38	0.29	174	270
2.50	0.0189	0.23	0.28	168	120
1.26	0.0292	0.13	0.25	150	260
3.79	0.0158	0.30	0.31	186	310

The rational method results are as follows for the 5' wide bio-swales:

Tributary Area[1], ac	C	Intensity, in/hr	Flow Rate, cfs
0.88	0.85	0.2	0.15
0.88	0.85	0.2	0.15

[1]See DMA exhibit for location of tributary areas.

Summary of Water Quality Flow Rates Tributary to 5' Vegetated Swales

The calculations are attached and summarized in the table below. The swales were assumed to have n=0.25, 3:1 side slopes, a 2-foot bottom width, and a longitudinal slope based on the existing topography.

Tributary Area, ac	Slope, ft/ft	Normal Depth, ft	Flow Velocity, fps	Minimum Swale Length, ft	Length on Site Plan, ft
0.88	0.021	0.22	0.26	156	130
0.88	0.024	0.21	0.28	168	160

Summary of Vegetated Swale Analyses

All of the vegetated swales shown on the site plan exceed or are very close to the minimum required length except for the swale serving the 2.50 acre area. During final engineering, some of the swales could be extended to achieve the needed length, or the cross-section geometry or slope could be adjusted to meet the treatment requirement.

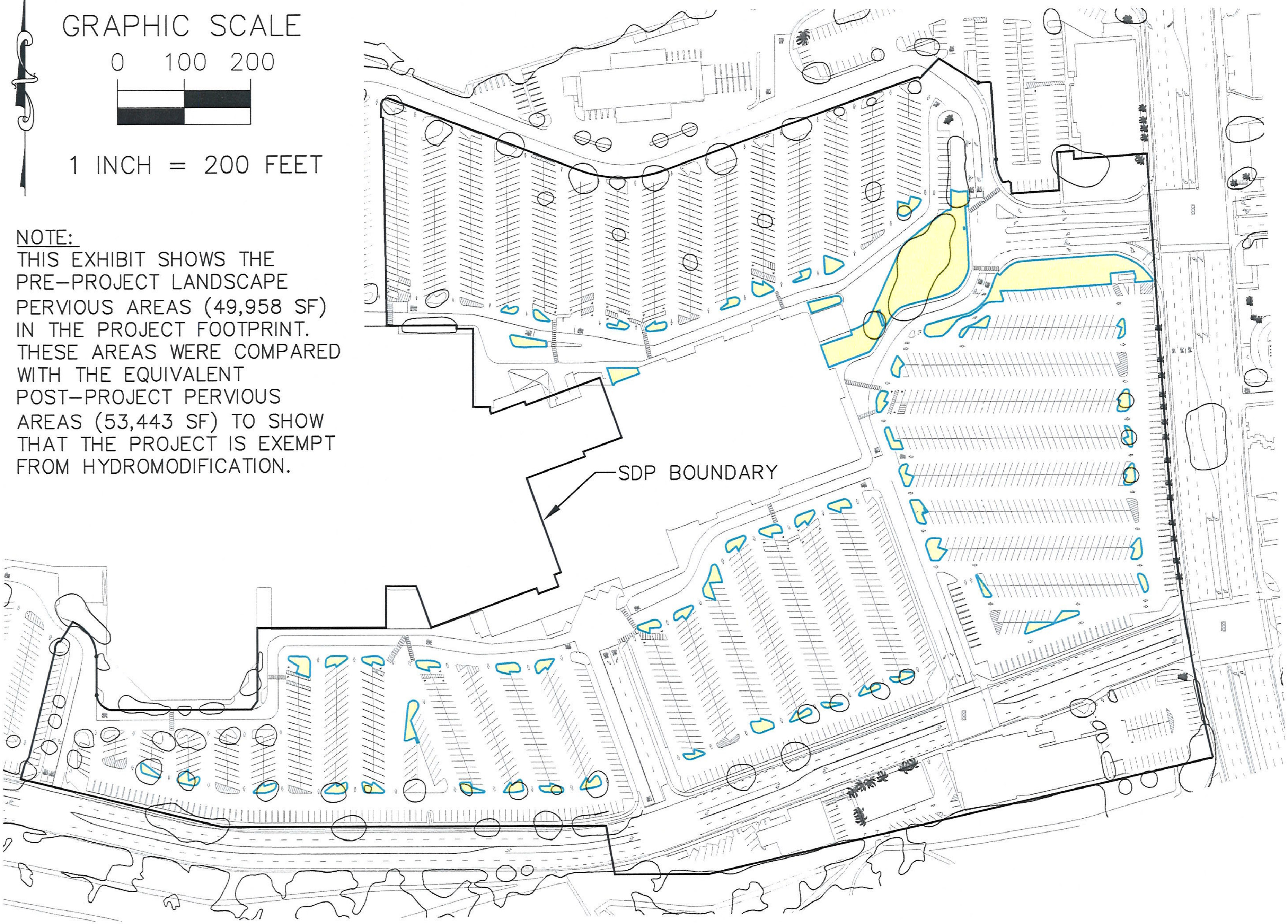
The above results show that vegetated swales are feasible BMPs to treat runoff from the southerly, easterly and northerly portions of the site. The calculations show that the vegetated swales are sufficient to treat on-site runoff. Assumptions were made for the roof drainage, which may vary during final engineering. In addition, the calculations do not include the benefits from the porous pavement, which can be accounted for during final engineering.

GRAPHIC SCALE

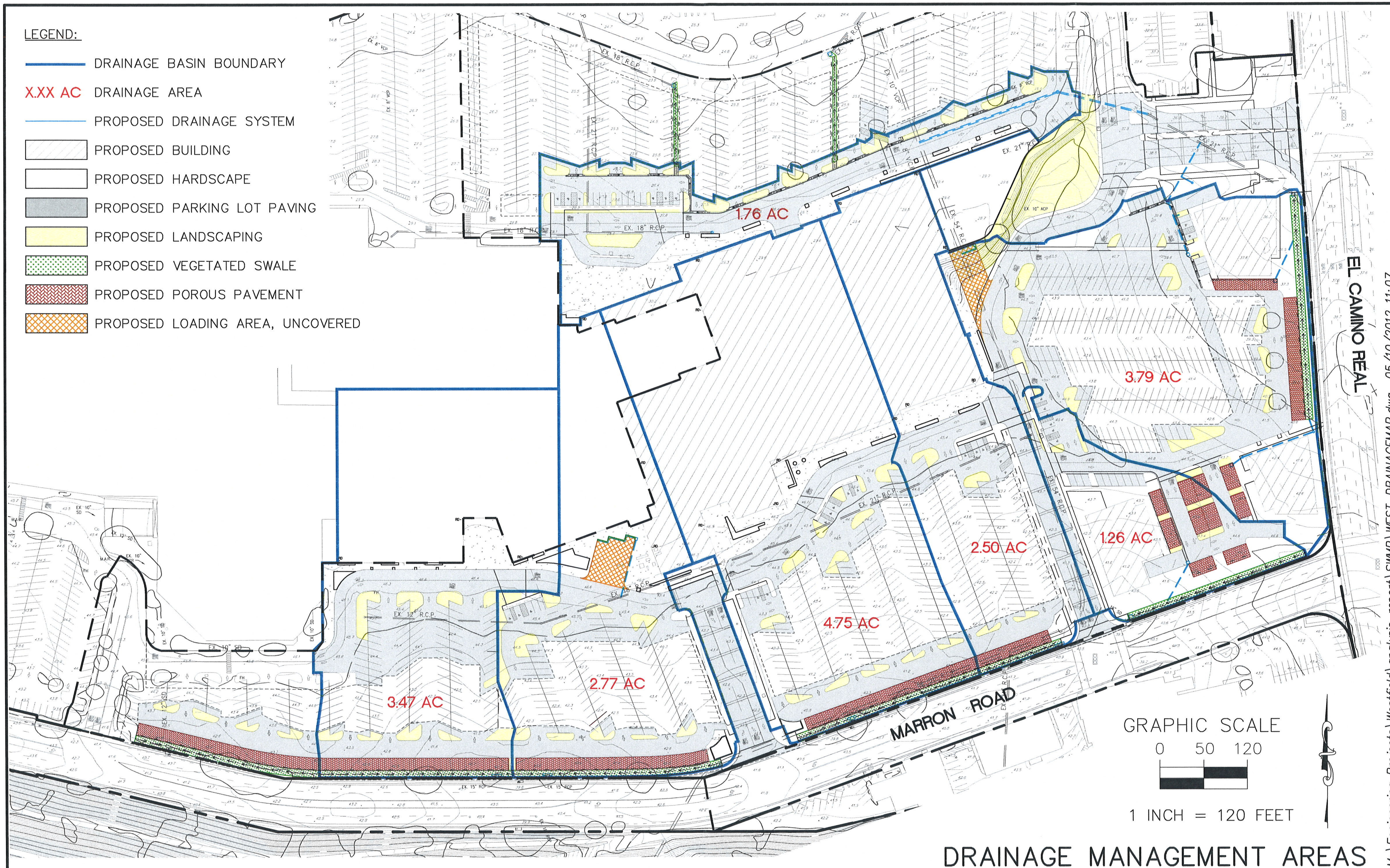
0 100 200

1 INCH = 200 FEET

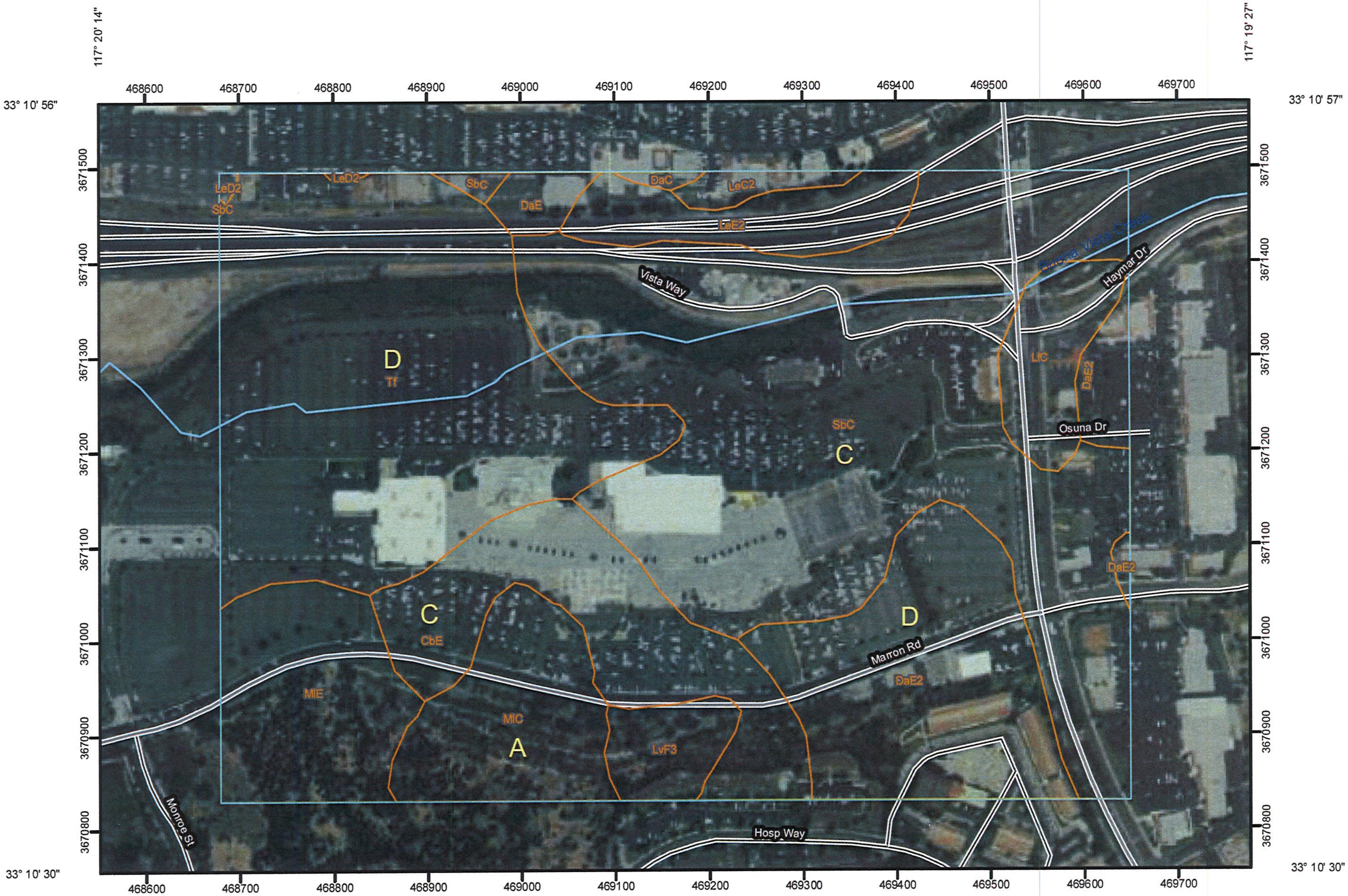
NOTE:
THIS EXHIBIT SHOWS THE PRE-PROJECT LANDSCAPE PERVIOUS AREAS (49,958 SF) IN THE PROJECT FOOTPRINT. THESE AREAS WERE COMPARED WITH THE EQUIVALENT POST-PROJECT PERVIOUS AREAS (53,443 SF) TO SHOW THAT THE PROJECT IS EXEMPT FROM HYDROMODIFICATION.



PRE-PROJECT PERVIOUS AREAS


LEGEND:
DRAINAGE BASIN BOUNDARY
X.XX AC DRAINAGE AREA
PROPOSED DRAINAGE SYSTEM
PROPOSED BUILDING
PROPOSED HARDSCAPE
PROPOSED PARKING LOT PAVING
PROPOSED LANDSCAPING
PROPOSED VEGETATED SWALE
PROPOSED POROUS PAVEMENT
PROPOSED LOADING AREA, UNCOVERED
1.76 AC
3.79 AC
2.50 AC
1.26 AC
4.75 AC
3.47 AC
2.77 AC
EL CAMINO REAL
MARRON ROAD
GRAPHIC SCALE
0 50 120
1 INCH = 120 FEET
05/10/2012 11:07
M:\Engineering Projects\Westfield\analysis_report\SWMP\WEST-DRAINAGEMAP.dwg
DRAINAGE MANAGEMENT AREAS

Soil Map—San Diego County Area, California



Map Scale: 1:5,820 if printed on A size (8.5" x 11") sheet.

Meters: 0, 50, 100, 200, 300

Feet: 0, 300, 600, 1,200, 1,800

HYDROLOGIC SOIL GROUPS ARE IN YELLOW

USDA Natural Resources Conservation Service

Web Soil Survey
National Cooperative Soil Survey

Table 3-1
RUNOFF COEFFICIENTS FOR URBAN AREAS

Land Use		Runoff Coefficient "C"				
			Soil Type			
NRCS Elements	County Elements	% IMPER.	A	B	C	D
Undisturbed Natural Terrain (Natural)	Permanent Open Space	0*	0.20	0.25	0.30	0.35
Low Density Residential (LDR)	Residential, 1.0 DU/A or less	10	0.27	0.32	0.36	0.41
Low Density Residential (LDR)	Residential, 2.0 DU/A or less	20	0.34	0.38	0.42	0.46
Low Density Residential (LDR)	Residential, 2.9 DU/A or less	25	0.38	0.41	0.45	0.49
Medium Density Residential (MDR)	Residential, 4.3 DU/A or less	30	0.41	0.45	0.48	0.52
Medium Density Residential (MDR)	Residential, 7.3 DU/A or less	40	0.48	0.51	0.54	0.57
Medium Density Residential (MDR)	Residential, 10.9 DU/A or less	45	0.52	0.54	0.57	0.60
Medium Density Residential (MDR)	Residential, 14.5 DU/A or less	50	0.55	0.58	0.60	0.63
High Density Residential (HDR)	Residential, 24.0 DU/A or less	65	0.66	0.67	0.69	0.71
High Density Residential (HDR)	Residential, 43.0 DU/A or less	80	0.76	0.77	0.78	0.79
Commercial/Industrial (N. Com)	Neighborhood Commercial	80	0.76	0.77	0.78	0.79
Commercial/Industrial (G. Com)	General Commercial	85	0.80	0.80	0.81	0.82
Commercial/Industrial (O.P. Com)	Office Professional/Commercial	90	0.83	0.84	0.84	0.85
Commercial/Industrial (Limited I.)	Limited Industrial	90	0.83	0.84	0.84	0.85
Commercial/Industrial (General I.)	General Industrial	95	0.87	0.87	0.87	0.87

*The values associated with 0% impervious may be used for direct calculation of the runoff coefficient as described in Section 3.1.2 (representing the pervious runoff coefficient, Cp, for the soil type), or for areas that will remain undisturbed in perpetuity. Justification must be given that the area will remain natural forever (e.g., the area is located in Cleveland National Forest).
DU/A = dwelling units per acre
NRCS = National Resources Conservation Service

Vegetated Swales Report

Label	Solve For	Friction Method	Roughness Coefficient
Trapezoidal Channel - 1	Normal Depth	Manning Formula	0.250
Trapezoidal Channel - 2	Normal Depth	Manning Formula	0.250
Trapezoidal Channel - 3	Normal Depth	Manning Formula	0.250
Trapezoidal Channel - 4	Normal Depth	Manning Formula	0.250
Trapezoidal Channel - 5	Normal Depth	Manning Formula	0.250
Trapezoidal Channel - 6	Normal Depth	Manning Formula	0.250

Channel Slope (ft/ft)	Normal Depth (ft)	Left Side Slope (ft/ft (H:V))	Right Side Slope (ft/ft (H:V))
0.01530	0.29	3.00	3.00
0.01670	0.25	3.00	3.00
0.01090	0.38	3.00	3.00
0.01890	0.23	3.00	3.00
0.02920	0.13	3.00	3.00
0.01580	0.30	3.00	3.00

Bottom Width (ft)	Discharge (ft^3/s)	Flow Area (ft^2)	Wetted Perimeter (ft)
6.00	0.59	2.00	7.84
6.00	0.47	1.67	7.57
6.00	0.81	2.75	8.43
6.00	0.43	1.52	7.44
6.00	0.21	0.84	6.83
6.00	0.64	2.08	7.91

Hydraulic Radius (ft)	Top Width (ft)	Critical Depth (ft)	Critical Slope (ft/ft)

Vegetated Swales Report

Hydraulic Radius (ft)	Top Width (ft)	Critical Depth (ft)	Critical Slope (ft/ft)
0.25	7.74	0.07	2.28522
0.22	7.49	0.06	2.39751
0.33	8.31	0.08	2.13939
0.20	7.36	0.05	2.44018
0.12	6.79	0.03	2.84716
0.26	7.81	0.07	2.24633

Velocity (ft/s)	Velocity Head (ft)	Specific Energy (ft)	Froude Number
0.30	0.00	0.29	0.10
0.28	0.00	0.25	0.10
0.29	0.00	0.39	0.09
0.28	0.00	0.23	0.11
0.25	0.00	0.13	0.13
0.31	0.00	0.30	0.10

Flow Type	Notes	Messages
Subcritical		
Subcritical		
Subcritical		
Subcritical		
Subcritical		
Subcritical		

Worksheet for North Bioswale - West Side

Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Roughness Coefficient	0.250	
Channel Slope	0.02100	ft/ft
Left Side Slope	3.00	ft/ft (H:V)
Right Side Slope	3.00	ft/ft (H:V)
Bottom Width	2.00	ft
Discharge	0.15	ft³/s

Results

Normal Depth	0.22	ft
Flow Area	0.57	ft²
Wetted Perimeter	3.36	ft
Hydraulic Radius	0.17	ft
Top Width	3.29	ft
Critical Depth	0.05	ft
Critical Slope	2.48650	ft/ft
Velocity	0.26	ft/s
Velocity Head	0.00	ft
Specific Energy	0.22	ft
Froude Number	0.11	
Flow Type	Subcritical	

GVF Input Data

Downstream Depth	0.00	ft
Length	0.00	ft
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	ft
Profile Description		
Profile Headloss	0.00	ft
Downstream Velocity	Infinity	ft/s
Upstream Velocity	Infinity	ft/s
Normal Depth	0.22	ft
Critical Depth	0.05	ft
Channel Slope	0.02100	ft/ft

Worksheet for North Bioswale - West Side

GVF Output Data

Critical Slope	2.48650	ft/ft

Worksheet for North Bioswale - East Side

Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Roughness Coefficient	0.250	
Channel Slope	0.02400	ft/ft
Left Side Slope	3.00	ft/ft (H:V)
Right Side Slope	3.00	ft/ft (H:V)
Bottom Width	2.00	ft
Discharge	0.15	ft^3/s

Results

Normal Depth	0.21	ft
Flow Area	0.54	ft^2
Wetted Perimeter	3.31	ft
Hydraulic Radius	0.16	ft
Top Width	3.24	ft
Critical Depth	0.05	ft
Critical Slope	2.48843	ft/ft
Velocity	0.28	ft/s
Velocity Head	0.00	ft
Specific Energy	0.21	ft
Froude Number	0.12	
Flow Type	Subcritical	

GVF Input Data

Downstream Depth	0.00	ft
Length	0.00	ft
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	ft
Profile Description		
Profile Headloss	0.00	ft
Downstream Velocity	Infinity	ft/s
Upstream Velocity	Infinity	ft/s
Normal Depth	0.21	ft
Critical Depth	0.05	ft
Channel Slope	0.02400	ft/ft

Worksheet for North Bioswale - East Side

GVF Output Data

Critical Slope	2.48843	ft/ft

Vegetated Swale

Design Considerations

- Tributary Area
- Area Required
- Slope
- Water Availability

Description

Vegetated swales are open, shallow channels with vegetation covering the side slopes and bottom that collect and slowly convey runoff flow to downstream discharge points. They are designed to treat runoff through filtering by the vegetation in the channel, filtering through a subsoil matrix, and/or infiltration into the underlying soils. Swales can be natural or manmade. They trap particulate pollutants (suspended solids and trace metals), promote infiltration, and reduce the flow velocity of stormwater runoff. Vegetated swales can serve as part of a stormwater drainage system and can replace curbs, gutters and storm sewer systems.

California Experience

Caltrans constructed and monitored six vegetated swales in southern California. These swales were generally effective in reducing the volume and mass of pollutants in runoff. Even in the areas where the annual rainfall was only about 10 inches/yr, the vegetation did not require additional irrigation. One factor that strongly affected performance was the presence of large numbers of gophers at most of the sites. The gophers created earthen mounds, destroyed vegetation, and generally reduced the effectiveness of the controls for TSS reduction.

Advantages

- If properly designed, vegetated, and operated, swales can serve as an aesthetic, potentially inexpensive urban development or roadway drainage conveyance measure with significant collateral water quality benefits.

Targeted Constituents

☑	Sediment	▲
☑	Nutrients	●
☑	Trash	●
☑	Metals	▲
☑	Bacteria	●
☑	Oil and Grease	▲
☑	Organics	▲

Legend ***(Removal Effectiveness)***

● Low ■ High

▲ Medium

CASQA
CALIFORNIA STORMWATER QUALITY ASSOCIATION

- Roadside ditches should be regarded as significant potential swale/buffer strip sites and should be utilized for this purpose whenever possible.

Limitations

- Can be difficult to avoid channelization.
- May not be appropriate for industrial sites or locations where spills may occur
- Grassed swales cannot treat a very large drainage area. Large areas may be divided and treated using multiple swales.
- A thick vegetative cover is needed for these practices to function properly.
- They are impractical in areas with steep topography.
- They are not effective and may even erode when flow velocities are high, if the grass cover is not properly maintained.
- In some places, their use is restricted by law: many local municipalities require curb and gutter systems in residential areas.
- Swales are mores susceptible to failure if not properly maintained than other treatment BMPs.

Design and Sizing Guidelines

- Flow rate based design determined by local requirements or sized so that 85% of the annual runoff volume is discharged at less than the design rainfall intensity.
- Swale should be designed so that the water level does not exceed 2/3rds the height of the grass or 4 inches, which ever is less, at the design treatment rate.
- Longitudinal slopes should not exceed 2.5%
- Trapezoidal channels are normally recommended but other configurations, such as parabolic, can also provide substantial water quality improvement and may be easier to mow than designs with sharp breaks in slope.
- Swales constructed in cut are preferred, or in fill areas that are far enough from an adjacent slope to minimize the potential for gopher damage. Do not use side slopes constructed of fill, which are prone to structural damage by gophers and other burrowing animals.
- A diverse selection of low growing, plants that thrive under the specific site, climatic, and watering conditions should be specified. Vegetation whose growing season corresponds to the wet season are preferred. Drought tolerant vegetation should be considered especially for swales that are not part of a regularly irrigated landscaped area.
- The width of the swale should be determined using Manning's Equation using a value of 0.25 for Manning's n.

Construction/Inspection Considerations

- Include directions in the specifications for use of appropriate fertilizer and soil amendments based on soil properties determined through testing and compared to the needs of the vegetation requirements.

- Install swales at the time of the year when there is a reasonable chance of successful establishment without irrigation; however, it is recognized that rainfall in a given year may not be sufficient and temporary irrigation may be used.

- If sod tiles must be used, they should be placed so that there are no gaps between the tiles; stagger the ends of the tiles to prevent the formation of channels along the swale or strip.

- Use a roller on the sod to ensure that no air pockets form between the sod and the soil.

- Where seeds are used, erosion controls will be necessary to protect seeds for at least 75 days after the first rainfall of the season.

Performance

The literature suggests that vegetated swales represent a practical and potentially effective technique for controlling urban runoff quality. While limited quantitative performance data exists for vegetated swales, it is known that check dams, slight slopes, permeable soils, dense grass cover, increased contact time, and small storm events all contribute to successful pollutant removal by the swale system. Factors decreasing the effectiveness of swales include compacted soils, short runoff contact time, large storm events, frozen ground, short grass heights, steep slopes, and high runoff velocities and discharge rates.

Conventional vegetated swale designs have achieved mixed results in removing particulate pollutants. A study performed by the Nationwide Urban Runoff Program (NURP) monitored three grass swales in the Washington, D.C., area and found no significant improvement in urban runoff quality for the pollutants analyzed. However, the weak performance of these swales was attributed to the high flow velocities in the swales, soil compaction, steep slopes, and short grass height.

Another project in Durham, NC, monitored the performance of a carefully designed artificial swale that received runoff from a commercial parking lot. The project tracked 11 storms and concluded that particulate concentrations of heavy metals (Cu, Pb, Zn, and Cd) were reduced by approximately 50 percent. However, the swale proved largely ineffective for removing soluble nutrients.

The effectiveness of vegetated swales can be enhanced by adding check dams at approximately 17 meter (50 foot) increments along their length (See Figure 1). These dams maximize the retention time within the swale, decrease flow velocities, and promote particulate settling. Finally, the incorporation of vegetated filter strips parallel to the top of the channel banks can help to treat sheet flows entering the swale.

Only 9 studies have been conducted on all grassed channels designed for water quality (Table 1). The data suggest relatively high removal rates for some pollutants, but negative removals for some bacteria, and fair performance for phosphorus.

Table 1 Grassed swale pollutant removal efficiency data							
Removal Efficiencies (% Removal)							
Study	TSS	TP	TN	NO_3	Metals	Bacteria	Type
Caltrans 2002	77	8	67	66	83-90	-33	dry swales
Goldberg 1993	67.8	4.5	-	31.4	42–62	-100	grassed channel
Seattle Metro and Washington Department of Ecology 1992	60	45	-	-25	2–16	-25	grassed channel
Seattle Metro and Washington Department of Ecology, 1992	83	29	-	-25	46–73	-25	grassed channel
Wang et al., 1981	80	-	-	-	70–80	-	dry swale
Dorman et al., 1989	98	18	-	45	37–81	-	dry swale
Harper, 1988	87	83	84	80	88–90	-	dry swale
Kercher et al., 1983	99	99	99	99	99	-	dry swale
Harper, 1988.	81	17	40	52	37–69	-	wet swale
Koon, 1995	67	39	-	9	-35 to 6	-	wet swale

While it is difficult to distinguish between different designs based on the small amount of available data, grassed channels generally have poorer removal rates than wet and dry swales, although some swales appear to export soluble phosphorus (Harper, 1988; Koon, 1995). It is not clear why swales export bacteria. One explanation is that bacteria thrive in the warm swale soils.

Siting Criteria

The suitability of a swale at a site will depend on land use, size of the area serviced, soil type, slope, imperviousness of the contributing watershed, and dimensions and slope of the swale system (Schueler et al., 1992). In general, swales can be used to serve areas of less than 10 acres, with slopes no greater than 5 %. Use of natural topographic lows is encouraged and natural drainage courses should be regarded as significant local resources to be kept in use (Young et al., 1996).

Selection Criteria (NCTCOG, 1993)

- Comparable performance to wet basins
- Limited to treating a few acres
- Availability of water during dry periods to maintain vegetation
- Sufficient available land area

Research in the Austin area indicates that vegetated controls are effective at removing pollutants even when dormant. Therefore, irrigation is not required to maintain growth during dry periods, but may be necessary only to prevent the vegetation from dying.

The topography of the site should permit the design of a channel with appropriate slope and cross-sectional area. Site topography may also dictate a need for additional structural controls. Recommendations for longitudinal slopes range between 2 and 6 percent. Flatter slopes can be used, if sufficient to provide adequate conveyance. Steep slopes increase flow velocity, decrease detention time, and may require energy dissipating and grade check. Steep slopes also can be managed using a series of check dams to terrace the swale and reduce the slope to within acceptable limits. The use of check dams with swales also promotes infiltration.

Additional Design Guidelines

Most of the design guidelines adopted for swale design specify a minimum hydraulic residence time of 9 minutes. This criterion is based on the results of a single study conducted in Seattle, Washington (Seattle Metro and Washington Department of Ecology, 1992), and is not well supported. Analysis of the data collected in that study indicates that pollutant removal at a residence time of 5 minutes was not significantly different, although there is more variability in that data. Therefore, additional research in the design criteria for swales is needed. Substantial pollutant removal has also been observed for vegetated controls designed solely for conveyance (Barrett et al, 1998); consequently, some flexibility in the design is warranted.

Many design guidelines recommend that grass be frequently mowed to maintain dense coverage near the ground surface. Recent research (Colwell et al., 2000) has shown mowing frequency or grass height has little or no effect on pollutant removal.

Summary of Design Recommendations

1) The swale should have a length that provides a minimum hydraulic residence time of at least 10 minutes. The maximum bottom width should not exceed 10 feet unless a dividing berm is provided. The depth of flow should not exceed 2/3rds the height of the grass at the peak of the water quality design storm intensity. The channel slope should not exceed 2.5%.

2) A design grass height of 6 inches is recommended.

3) Regardless of the recommended detention time, the swale should be not less than 100 feet in length.

4) The width of the swale should be determined using Manning's Equation, at the peak of the design storm, using a Manning's n of 0.25.

5) The swale can be sized as both a treatment facility for the design storm and as a conveyance system to pass the peak hydraulic flows of the 100-year storm if it is located "on-line." The side slopes should be no steeper than 3:1 (H:V).

6) Roadside ditches should be regarded as significant potential swale/buffer strip sites and should be utilized for this purpose whenever possible. If flow is to be introduced through curb cuts, place pavement slightly above the elevation of the vegetated areas. Curb cuts should be at least 12 inches wide to prevent clogging.

7) Swales must be vegetated in order to provide adequate treatment of runoff. It is important to maximize water contact with vegetation and the soil surface. For general purposes, select fine, close-growing, water-resistant grasses. If possible, divert runoff (other than necessary irrigation) during the period of vegetation

establishment. Where runoff diversion is not possible, cover graded and seeded areas with suitable erosion control materials.

Maintenance

The useful life of a vegetated swale system is directly proportional to its maintenance frequency. If properly designed and regularly maintained, vegetated swales can last indefinitely. The maintenance objectives for vegetated swale systems include keeping up the hydraulic and removal efficiency of the channel and maintaining a dense, healthy grass cover.

Maintenance activities should include periodic mowing (with grass never cut shorter than the design flow depth), weed control, watering during drought conditions, reseeding of bare areas, and clearing of debris and blockages. Cuttings should be removed from the channel and disposed in a local composting facility. Accumulated sediment should also be removed manually to avoid concentrated flows in the swale. The application of fertilizers and pesticides should be minimal.

Another aspect of a good maintenance plan is repairing damaged areas within a channel. For example, if the channel develops ruts or holes, it should be repaired utilizing a suitable soil that is properly tamped and seeded. The grass cover should be thick; if it is not, reseed as necessary. Any standing water removed during the maintenance operation must be disposed to a sanitary sewer at an approved discharge location. Residuals (e.g., silt, grass cuttings) must be disposed in accordance with local or State requirements. Maintenance of grassed swales mostly involves maintenance of the grass or wetland plant cover. Typical maintenance activities are summarized below:

- Inspect swales at least twice annually for erosion, damage to vegetation, and sediment and debris accumulation preferably at the end of the wet season to schedule summer maintenance and before major fall runoff to be sure the swale is ready for winter. However, additional inspection after periods of heavy runoff is desirable. The swale should be checked for debris and litter, and areas of sediment accumulation.

- Grass height and mowing frequency may not have a large impact on pollutant removal. Consequently, mowing may only be necessary once or twice a year for safety or aesthetics or to suppress weeds and woody vegetation.

- Trash tends to accumulate in swale areas, particularly along highways. The need for litter removal is determined through periodic inspection, but litter should always be removed prior to mowing.

- Sediment accumulating near culverts and in channels should be removed when it builds up to 75 mm (3 in.) at any spot, or covers vegetation.

- Regularly inspect swales for pools of standing water. Swales can become a nuisance due to mosquito breeding in standing water if obstructions develop (e.g. debris accumulation, invasive vegetation) and/or if proper drainage slopes are not implemented and maintained.

Cost

Construction Cost

Little data is available to estimate the difference in cost between various swale designs. One study (SWRPC, 1991) estimated the construction cost of grassed channels at approximately \$0.25 per ft^2. This price does not include design costs or contingencies. Brown and Schueler (1997) estimate these costs at approximately 32 percent of construction costs for most stormwater management practices. For swales, however, these costs would probably be significantly higher since the construction costs are so low compared with other practices. A more realistic estimate would be a total cost of approximately \$0.50 per ft^2, which compares favorably with other stormwater management practices.

Table 2 Swale Cost Estimate (SEWRPC, 1991)

Component	Unit	Extent	Unit Cost			Total Cost		
			Low	Moderate	High	Low	Moderate	High
Mobilization / Demobilization-Light	Swale	1	$107	$274	$441	$107	$274	$441
Site Preparation								
Clearing[b]	Acre	0.5	$2,200	$3,800	$5,400	$1,100	$1,900	$2,700
Grubbing[c]	Acre	0.25	$3,800	$5,200	$6,600	$950	$1,300	$1,650
General Excavation[d]	Yd^3	372	$2.10	$3.70	$5.30	$781	$1,376	$1,972
Level and Till[e]	Yd^2	1,210	$0.20	$0.35	$0.50	$242	$424	$605
Sites Development								
Salvaged Topsoil Seed, and Mulch[f]	Yd^2	1,210	$0.40	$1.00	$1.60	$484	$1,210	$1,936
Sod[g]	Yd^2	1,210	$1.20	$2.40	$3.60	$1,452	$2,904	$4,356
Subtotal	--	--	--	--	--	$5,116	$9,388	$13,660
Contingencies	Swale	1	25%	25%	25%	$1,279	$2,347	$3,415
Total	--	--	--	--	--	$6,395	$11,735	$17,075

Source: (SEWRPC, 1991)

Note: Mobilization/demobilization refers to the organization and planning involved in establishing a vegetative swale.

[a] Swale has a bottom width of 1.0 foot, a top width of 10 feet with 1:3 side slopes, and a 1,000-foot length.

[b] Area cleared = (top width + 10 feet) x swale length.

[c] Area grubbed = (top width x swale length).

[d] Volume excavated = (0.67 x top width x swale depth) x swale length (parabolic cross-section).

[e] Area tilled = $\left(\text{top width} + \frac{8(\text{swale depth}^2)}{3(\text{top width})}\right)$ x swale length (parabolic cross-section).

[f] Area seeded = area cleared x 0.5.

[g] Area sodded = area cleared x 0.5.

Table 3 Estimated Maintenance Costs (SEWRPC, 1991)

Component	Unit Cost	Swale Size (Depth and Top Width)		Comment
		1.5 Foot Depth, One-Foot Bottom Width, 10-Foot Top Width	3-Foot Depth, 3-Foot Bottom Width, 21-Foot Top Width	
Lawn Mowing	$0.85 / 1,000 ft^2/ mowing	$0.14 / linear foot	$0.21 / linear foot	Lawn maintenance area=(top width + 10 feet) x length. Mow eight times per year
General Lawn Care	$9.00 / 1,000 ft^2/ year	$0.18 / linear foot	$0.28 / linear foot	Lawn maintenance area = (top width + 10 feet) x length
Swale Debris and Litter Removal	$0.10 / linear foot / year	$0.10 / linear foot	$0.10 / linear foot	–
Grass Reseeding with Mulch and Fertilizer	$0.30 / yd^2	$0.01 / linear foot	$0.01 / linear foot	Area revegetated equals 1% of lawn maintenance area per year
Program Administration and Swale Inspection	$0.15 / linear foot / year, plus $25 / inspection	$0.15 / linear foot	$0.15 / linear foot	Inspect four times per year
Total	--	**$0.58 / linear foot**	**$ 0.75 / linear foot**	–

Maintenance Cost

Caltrans (2002) estimated the expected annual maintenance cost for a swale with a tributary area of approximately 2 ha at approximately $2,700. Since almost all maintenance consists of mowing, the cost is fundamentally a function of the mowing frequency. Unit costs developed by SEWRPC are shown in Table 3. In many cases vegetated channels would be used to convey runoff and would require periodic mowing as well, so there may be little additional cost for the water quality component. Since essentially all the activities are related to vegetation management, no special training is required for maintenance personnel.

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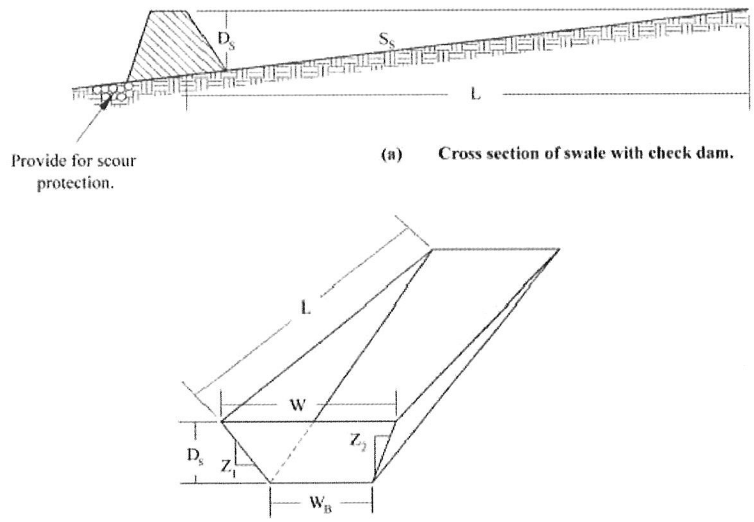


(a) Cross section of swale with check dam.

(b) Dimensional view of swale impoundment area.

Notation:

L = Length of swale impoundment area per check dam (ft)
D_S = Depth of check dam (ft)
S_S = Bottom slpe of swale (ft/ft)
W = Top width of check dam (ft)
W_B = Bottom width of check dam (ft)
$Z_{1\&2}$ = Ratio of horizontal to vertical change in swale side slope (ft/ft)

FloGard® LoPro Trench Drain Filter

The **FloGard® LoPro Trench Drain Filter** is a modular filter designed to collect particles, debris, metals and petroleum hydrocarbons from stormwater runoff into trench drain systems. It includes a UV-resistant woven geo-textile wrapped around a perforated core encapsulating an absorbent which is easily replaced, providing for flexibility, ease of maintenance, and economy.

For the narrow and constricted areas often found in trench drains, the FloGard® LoPro Trench Drain Filter provides an effective solution to comply with stormwater runoff issues. The units perform as an effective filtering device at low flows ("first flush") and, because of the built-in high flow bypass, will not impede the drainage system's maximum design flow.

FloGard® LoPro Trench Drain Filters are available in sizes to fit common trench drain sizes, or are available as complete packaged "plug and play" units including filter integrated with steel trench drain.

SPECIFIER CHART

MODEL	FILTER TYPE	TRENCH WIDTH "ID" (CLEAR OPENING)	MINIMUM TRENCH DEPTH (FROM BOTTOM OF GRATE)	SOLIDS STORAGE CAPACITY CUBIC FEET **	FILTERED FLOW CUBIC FEET / SECOND **	TOTAL BYPASS CAPACITY CUBIC FEET /SECOND
FG-TDOF3	PIPE*	3.0	6.5	0.1	0.5	0.1
FG-TDOF4	PIPE*	4.0	6.5	0.2	0.5	0.1
FG-TDOF6	PIPE	6.0	6.5	0.4	0.5	0.2
FG-TDOF8	PIPE	8.0	6.5	0.7	0.5	0.3
FG-TDOF10	PIPE	10.0	6.5	0.9	0.5	0.5
FG-TDOF12	PIPE	12.0	6.5	0.9	1.0	0.6
FG-TDOF18	PIPE	18.0	6.5	1.3	1.5	1.1
FG-TDOF24	PIPE	24.0	6.5	1.8	2.0	1.5
FG-TDOA6	PANEL	6.0	4.5	0.4	0.2	0.2
FG-TDOA8	PANEL	8.0	4.5	0.7	0.2	0.3
FG-TDOA10	PANEL	10.0	4.5	0.8	0.3	0.5
FG-TDOA12	PANEL	12.0	4.5	1.0	0.4	0.6
FG-TDOA18	PANEL	18.0	4.5	1.4	0.8	1.1
FG-TDOA24	PANEL	24.0	4.5	1.8	1.1	1.5

*** ALTERNATE ADAPTER CONFIGURATION.**

**** CAPACITY PER 4-FT SEGMENT USED.**

Rev. 11.29.11

GENERAL SPECIFICATIONS FOR MAINTENANCE OF *FLOGARD® LOPRO TRENCH DRAIN FILTERS*

SCOPE:

Federal, State and Local Clean Water Act regulations and those of insurance carriers require that stormwater filtration systems be maintained and serviced on a recurring basis. The intent of the regulations is to ensure that the systems, on a continuing basis, efficiently remove pollutants from stormwater runoff thereby preventing pollution of the nation's water resources. These Specifications apply to the FloGard® LoPro Trench Drain Filter.

RECOMMENDED FREQUENCY OF SERVICE:

Drainage Protection Systems (DPS) recommends that installed FloGard® LoPro Trench Drain Filters be serviced on a recurring basis. Ultimately, the frequency depends on the amount of runoff, pollutant loading and interference from debris (leaves, vegetation, cans, paper, etc.); however, it is recommended that each installation be serviced a minimum of three times per year, with a change of filter medium once per year. DPS technicians are available to do an on-site evaluation, upon request.

RECOMMENDED TIMING OF SERVICE:

DPS guidelines for the timing of service are as follows:

1. For areas with a definite rainy season: Prior to, during and following the rainy season.
2. For areas subject to year-round rainfall: On a recurring basis (at least three times per year).
3. For areas with winter snow and summer rain: Prior to and just after the snow season and during the summer rain season.
4. For installed devices not subject to the elements (wash racks, parking garages, etc.): On a recurring basis (no less than three times per year).

SERVICE PROCEDURES:

1. The trench drain grate(s) shall be removed and set to one side.
2. The service shall commence with collection and removal of sediment and debris (litter, leaves, papers, cans, etc.)
3. The trench drain shall be visually inspected for defects and possible illegal dumping. If illegal dumping has occurred, the proper authorities and property owner representative shall be notified as soon as practicable.
4. Using an industrial vacuum, the collected materials shall be removed from the filter liner. (Note: DPS uses a truck-mounted vacuum for servicing FloGard® LoPro Trench Drain Filters.)
5. When all of the collected materials have been removed, the filter assembly shall be removed from the drainage inlet. The outer filter liner shall be removed from the filter assembly and filter medium pouches shall be removed by unsnapping the tether from the interior ring and set to one side. The filter liner, PVC body and fittings shall be inspected for continued serviceability. Minor damage or defects found shall be corrected on the spot and a notation made on the Maintenance Record. More extensive deficiencies that affect the efficiency of the filter (torn liner, etc.), if approved by the customer representative, will be corrected and a quote submitted to the representative along with the Maintenance Record.
6. The filter liner and filter medium pouches shall be inspected for defects and continued serviceability and replaced as necessary and the pouch tethers re-attached to the PVC body interior ring.
7. The grate(s) shall be replaced.

REPLACEMENT AND DISPOSAL OF EXPOSED FILTER MEDIUM AND COLLECTED DEBRIS

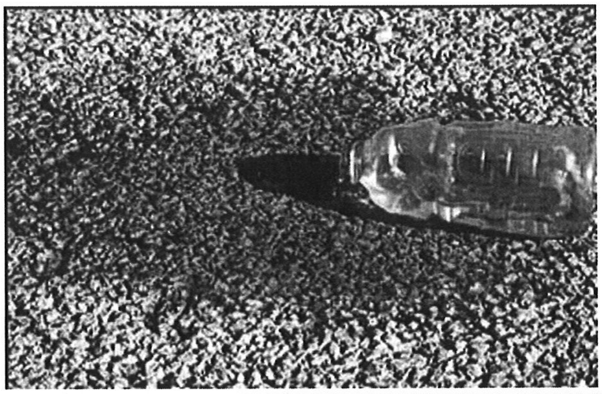
The frequency of filter medium pouch exchange will be in accordance with the existing DPS-Customer Maintenance Contract. DPS recommends that the medium be changed at least once per year. During the appropriate service, or if so determined by the service technician during a non-scheduled service, the filter medium pouches will be replaced. Once the exposed pouches and debris have been placed in the container, DPS has possession and must dispose of it in accordance with local, state and federal agency requirements.

DPS also has the capability of servicing all types of catch basin inserts and catch basins without inserts, underground oil/water separators, stormwater interceptors and other treatment devices. All DPS personnel are highly qualified technicians and are confined space trained and certified. Call us at (888) 950-8826 for further information and assistance.

04/07

3.3.5 Porous Concrete

Limited Application
Structural Stormwater Control



Description: Porous concrete is the term for a mixture of coarse aggregate, portland cement and water that allow for rapid infiltration of water and overlays a stone aggregate reservoir. This reservoir provides temporary storage as runoff infiltrates into underlying permeable soils and/or out through an underdrain system.

REASONS FOR LIMITED USE

- Traditionally high failure rate and short life span
- Intended for low volume auto traffic areas, or for overflow parking applications
- High maintenance requirements
- Special attention to design and construction needed
- Should not be used in areas of soils with low permeability, well head protection zones, or recharge areas of water supply aquifer recharge areas
- Restrictions on use by heavy vehicles

KEY CONSIDERATIONS

- Soil infiltration rate of 0.5 in/hr or greater required
- Excavated area filled with stone media; gravel and sand filter layers with observation well
- Pre-treat runoff if sediment present
- Provides reduction in runoff volume
- Somewhat higher cost when compared to conventional pavements
- Potential for high failure rate if poorly designed, poorly constructed, not adequately maintained or used in unstabilized areas
- Potential for groundwater contamination

STORMWATER MANAGEMENT SUITABILITY

☑ **Water Quality**
✪ **Channel / Flood Protection**

SPECIAL APPLICATIONS

☐ **Pretreatment**
☑ **High Density / Ultra-Urban**
☑ **Other:** Overflow Parking, Driveways & related uses

Residential Subdivision Use: *Yes*
(in common areas that are maintained)

✪ in certain situations

3.3.5.1 General Description

Porous concrete (also referred to as *enhanced porosity concrete*, *porous concrete*, *portland cement pervious pavement* and *pervious pavement*) is a subset of a broader family of pervious pavements including porous asphalt, and various kinds of grids and paver systems. Porous concrete is thought to have a greater ability than porous asphalt to maintain its porosity in hot weather and thus is provided as a limited application control. Although, porous concrete has seen growing use in Georgia, there is still very limited practical experience with this measure. According to the U.S. EPA, porous pavement sites have had a high failure rate – approximately 75 percent. Failure has been attributed to poor design, inadequate construction techniques, and soils with low permeability, heavy vehicular traffic and poor maintenance. This measure, if used, should be carefully monitored over the life of the development.

Porous concrete consists of a specially formulated mixture of portland cement, uniform, open graded course aggregate, and water. The concrete layer has a high permeability often many times that of the underlying permeable soil layer, and allows rapid percolation of rainwater through the surface and into the layers beneath. The void space in porous concrete is in the 15% to 22% range compared to three to five percent for conventional pavements. The permeable surface is placed over a layer of open-graded gravel and crushed stone. The void spaces in the stone act as a storage reservoir for runoff.

Porous concrete is designed primarily for stormwater quality, i.e. the removal of stormwater pollutants. However, they can provide limited runoff quantity control, particularly for smaller storm events. For some smaller sites, trenches can be designed to capture and infiltrate the channel protection volume (Cp_v) in addition to WQ_v. Porous concrete will need to be used in conjunction with another structural control to provide overbank and extreme flood protection, if required.

Modifications or additions to the standard design have been used to pass flows and volumes in excess of the water quality volume, or to increase storage capacity or treatment. These include:

- Placing a perforated pipe near the top of the crushed stone reservoir to pass excess flows after the reservoir is filled
- Providing surface detention storage in a parking lot, adjacent swale, or detention pond with suitable overflow conveyance
- Connecting the stone reservoir layer to a stone filled trench
- Adding a sand layer and perforated pipe beneath the stone layer for filtration of the water quality volume
- Placing an underground detention tank or vault system beneath the layers

The infiltration rate of the soils in the sub-grade should be adequate to support drawdown of the entire runoff capture volume within 24 to 48 hours. Special care must be taken during construction to avoid undue compaction of the underlying soils which could affect the soils' infiltration capability.

Porous concrete systems are typically used in low-traffic areas such as the following types of applications:

- Parking pads in parking lots
- Overflow parking areas
- Residential street parking lanes
- Recreational trails
- Golf cart and pedestrian paths
- Emergency vehicle and fire access lanes

Slopes should be flat or gentle to facilitate infiltration versus runoff and the seasonally high water table or bedrock should be a minimum of two feet below the bottom of the gravel layer if infiltration is to be relied on to remove the stored volume.

Porous concrete has the positive characteristics of volume reduction due to infiltration, groundwater recharge, and an ability to blend into the normal urban landscape relatively unnoticed. It also allows a reduction in the cost of other stormwater infrastructure, a fact that may offset the greater placement cost somewhat.

A drawback is the cost and complexity of porous concrete systems compared to conventional pavements. Porous concrete systems require a very high level of construction workmanship to ensure that they function as designed. They experience a high failure rate if they are not designed, constructed and maintained properly.

Like other infiltration controls, porous concrete should not be used in areas that experience high rates of wind erosion or in drinking water aquifer recharge areas.

3.3.5.2 Pollutant Removal Capabilities

As they provide for the infiltration of stormwater runoff, porous concrete systems have a high removal of both soluble and particulate pollutants, where they become trapped, absorbed or broken down in the underlying soil layers. Due to the potential for clogging, porous concrete surfaces should not be used for the removal of sediment or other coarse particulate pollutants.

The following design pollutant removal rates are conservative average pollutant reduction percentages for design purposes derived from sampling data, modeling and professional judgment.

- **Total Suspended Solids – not applicable**
- **Total Phosphorus – 50%**
- **Total Nitrogen – 65%**

- **Fecal Coliform – insufficient data**
- **Heavy Metals – 60%**

Pollutant removal can be improved through routine vacuum sweeping and high pressure washing, insuring a drainage time of at least 24 hours, pretreating the runoff, having organic material in the subsoil, and using clean washed aggregate (EPA, 1999).

3.3.5.3 Design Criteria and Specifications

- Porous concrete systems can be used where the underlying in-situ sub-soils have an infiltration rate greater than 0.5 inches per hour. Therefore, porous concrete systems are not suitable on sites with hydrologic group D or most group C soils, or soils with a high (> 30%) clay content. During construction and preparation of the sub-grade, special care must be taken to avoid compaction of the soils.
- Porous concrete systems should typically be used in applications where the pavement receives tributary runoff only from impervious areas. Actual pervious surface area sizing will depend on achieving a 24-hour minimum and 48-hour maximum draw down time for the design storm volume.
- If runoff is coming from adjacent pervious areas, it is important that those areas be fully stabilized to reduce sediment loads and prevent clogging of the porous paver surface. Pretreatment using filter strips or vegetated swales for removal of course sediments are recommended. (see sections 3.3.1 and 3.3.2)
- Porous concrete systems should not be used on slopes greater than 5% with slopes of no greater than 2% recommended. For slopes greater than 1% barriers perpendicular to the direction of drainage should be installed in sub-grade material to keep it from washing away, or filter fabric should be placed at the bottom and sides of the aggregate to keep soil from migrating into the aggregate and reducing porosity.
- A minimum of four feet of clearance is recommended between the bottom of the gravel base course and underlying bedrock or the seasonally high groundwater table.
- Porous concrete systems should be sited at least 10 feet down-gradient from buildings and 100 feet away from drinking water wells.
- To protect groundwater from potential contamination, runoff from designated hotspot land uses or activities must not be infiltrated. Porous concrete should not be used for manufacturing and industrial sites, where there is a potential for high concentrations of soluble pollutants and heavy metals. In addition, porous concrete should not be considered for areas with a high pesticide concentration. Porous concrete is also not suitable in areas with karst geology without adequate geotechnical testing by qualified individuals and in accordance with Columbia County requirements.
- Porous concrete system designs must use some method to convey larger storm event flows to the conveyance system. One option is to use storm drain inlets set slightly above the elevation of the pavement. This would allow for some ponding above the surface, but would accept bypass flows that are too large to be infiltrated by the porous concrete system, or if the surface clogs.
- For the purpose of sizing downstream conveyance and structural control system, porous concrete surface areas can be assumed to 45% impervious. For other values, submit supporting data to Columbia County for review and approval. In addition, credit can be taken for the runoff volume infiltrated from other impervious areas using the methodology in Section 3.1.
- For treatment control, the design volume should be, at a minimum, equal to the water quality volume. The water quality storage volume is contained in the surface layer, the aggregate reservoir, and the sub-grade above the seasonal high water table – if the sub-grade is sandy. The storm duration (fill time) is normally short compared to the infiltration rate of the sub-grade; duration of two hours can be used for design purposes. The total storage volume in a layer is equal to the percent of voids times the volume of the layer. Alternately storage may be created on the surface through temporary ponding, though this would tend to accelerate clogging if course sediment or mud settles out on the surface.

- The cross-section typically consists of four layers, as shown in Figure 3.3.5-1. The aggregate reservoir can sometimes be avoided or minimized if the sub-grade is sandy and there is adequate time to infiltrate the necessary runoff volume into the sandy soil without by-passing the water quality volume. Descriptions of each of the layers is presented below:

  Porous Concrete Layer – The porous concrete layer consists of an open-graded concrete mixture usually ranging from depths of 2 to 4 inches depending on required bearing strength and pavement design requirements. Porous concrete can be assumed to contain 18 percent voids (porosity = 0.18) for design purposes. Thus, for example, a 4-inch thick porous concrete layer would hold 0.72 inches of rainfall. The omission of the fine aggregate provides the porosity of the porous pavement. To provide a smooth riding surface and to enhance handling and placement a coarse aggregate of ⅜-inch maximum size is normally used. Use GDOT No. 8 coarse aggregate (⅜ to No. 16) per ASTM C 33 or No. 89 coarse aggregate (⅜ to No. 50) per ASTM D 448. See the GCPA specifications (referenced).

  Top Filter Layer – Consists of a 0.5 inch diameter crushed stone to a depth of 1 to 2 inches. This layer serves to stabilize the porous asphalt layer. Can be combined with reservoir layer using suitable stone.

  Reservoir Layer – The reservoir gravel base course consists of washed, bank-run gravel, 1.5 to 2.5 inches in diameter with a void space of about 40% (GADOT No.3 Stone). The depth of this layer depends on the desired storage volume, which is a function of the soil infiltration rate and void spaces, but typically ranges from two to four feet. The layer must have a minimum depth of nine inches. The layer should be designed to drain completely in 48 hours. Also, the layer should be designed to store at a minimum the water quality volume (WQ_v). Aggregate contaminated with soil shall not be used. A porosity value (void space/total volume) of 0.32 should be used in calculations unless aggregate specific data exist. .

  Bottom Filter Layer – The surface of the sub-grade should be a 6-inch layer of sand (ASTM C-33 concrete sand or GADOT Fine Aggregate Size No. 10) or a 2 inch thick layer of 0.5 inch crushed stone, and be completely flat to promote infiltration across the entire surface. This layer serves to stabilize the reservoir layer, to protect the underlying soil from compaction, and act as the interface between the reservoir layer and the filter fabric covering the underlying soil.

  Filter Fabric – It is very important to line the entire trench area, including the sides, with filter fabric prior to placement of the aggregate. The filter fabric serves a very important function by inhibiting soil from migrating into the reservoir layer and reducing storage capacity. Fabric should be MIRFI # 14 N or equivalent.

  Underlying Soil – The underlying soil should have an infiltration capacity of at least 0.5 in/hr, but preferably greater than 0.50 in/hr. as initially determined from NRCS soil textural classification, and subsequently confirmed by field geotechnical tests. The minimum geotechnical testing is one test hole per 5000 square feet, with a minimum of two borings per facility (taken within the proposed limits of the facility). Infiltration trenches cannot be used in fill soils. Soils at the lower end of this range may not be suited for a full infiltration system. Test borings are recommended to determine the soil classification, seasonal high ground water table elevation, and impervious substrata, and an initial estimate of permeability. Often a double-ring infiltrometer test is done at sub-grade elevation to determine the impermeable layer, and, for safety, one-half the measured value is allowed for infiltration calculations.

- The pit excavation should be limited to the width and depth specified in the design. Excavated material should be placed away from the open trench as not to jeopardize the stability of the trench sidewalls. The bottom of the excavated trench should not be loaded so as to cause compaction, and should be scarified prior to placement of sand. The sides of the trench shall be trimmed of all large roots. The sidewalls shall be uniform with no voids and scarified prior to backfilling. All infiltration trench facilities should be protected during site construction, and should be constructed after upstream areas have been stabilized.

- An observation well consisting of perforated PVC pipe 4 to 6 inches in diameter should be placed at the downstream end of the facility and protected. The well should be used to determine actual infiltration rates.
- A warning sign should be placed at the facility that states, "Porous Paving used on this site to reduce pollution. Do not resurface with non-porous material.
- Details of construction of the concrete layer are beyond the scope of this manual. However, construction of porous concrete is exacting, and requires special handling, timing, and placement to perform adequately. Porous concrete can only be installed by a contractor approved by Columbia County and trained in porous concrete installation.

3.3.5.4 Inspection and Maintenance Requirements

Activity	Schedule
• Initial inspection	Monthly for three months after installation
• Ensure that the porous paver surface is free of sediment	Monthly
• Ensure that the contributing and adjacent area is stabilized and mowed, with clippings removed	As needed, based on inspection
• Vacuum sweep porous concrete surface followed by high pressure hosing to keep pores free of sediment	Four times a year
• Inspect the surface for deterioration or spalling • Check to make sure that the system dewaters between storms	Annually
• Spot clogging can be handled by drilling half-inch holes through the pavement every few feet • Rehabilitation of the porous concrete system, including the top and base course as needed	Upon failure

Table 3.3.5-1 Typical Maintenance Activities for Porous Concrete Systems

To ensure proper maintenance of porous pavement, a carefully worded maintenance agreement is essential. It should include specific the specific requirements and establish the responsibilities of the property owner and provide for enforcement.

3.3.5.5 Example Schematics

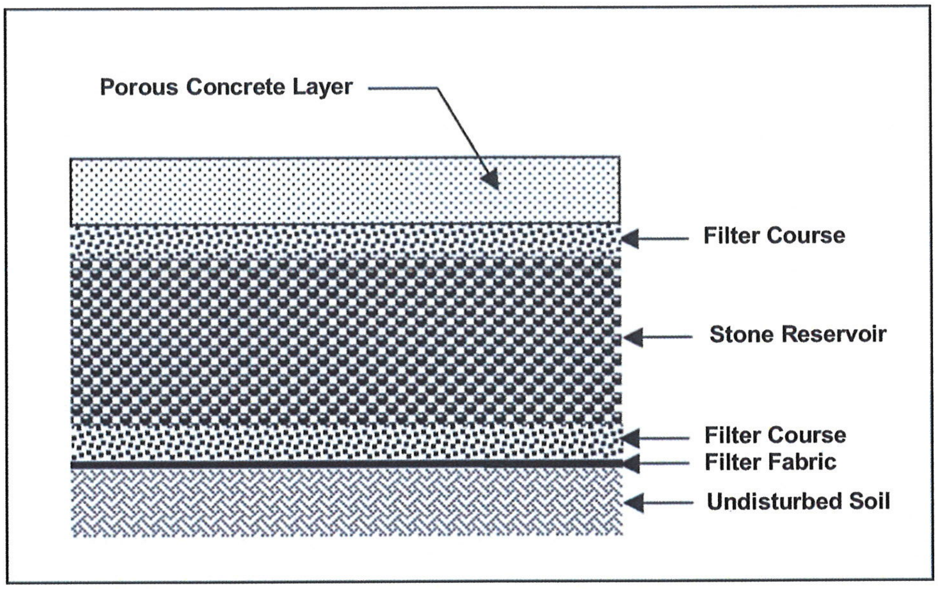


Figure 3.3.5-1 Porous Concrete System Section
(Modified From: LAC 2000)

Figure 3.3.5-2 Porous Concrete System Installation

Figure 3.3.5-3 Typical Porous Concrete System Applications
(Photos by Bruce Ferguson, Don Wade)

3.3.5.6 Design Example

** Data used in this example is not site specific. Site specific data will be required for actual design. **

Data

A 1.5 acre overflow parking area is to be designed to provide water quality treatment using porous concrete for at least part of the site to handle the runoff from the whole overflow parking area. Initial data shows:

- Borings show depth to water table is 5.0 feet
- Boring and infiltrometer tests show sand-loam with percolation rate (k) of 1.02 inches/hr
- Structural design indicates the thickness of the porous concrete must be at least three inches

Water Quality Volume

$$R_v = 0.05 + 0.009\ I \quad \text{(where I = 100 percent)}$$
$$= 0.95$$

$$WQ_v = 1.2\ R_v\ A/12 = 1.2 * 0.95 * 1.5/12 \quad \text{(converted to cubic feet from acre-feet)}$$
$$= 6{,}207 \text{ cubic feet}$$

Surface Area

A porosity value n = 0.32 should be used for the gravel and 0.18 for the concrete layer.

All infiltration systems should be designed to fully de-water the entire WQ_v within 24 to 48 hours after the rainfall event at the design percolation rate.

A fill time T = 2 hours can be used for most designs

Chose a depth of gravel pit of three feet (including layer under concrete) which fits the site with a two foot minimum to water table (other lesser depths could be chosen, making the surface area larger). The minimum surface area of the trench can be determined, in a manner similar to the infiltration trench, from the following equation:

$$A = WQ_v / (n_g d_g + kT/12 + n_p d_p)$$
$$= 6{,}207 / (0.32 * 3 + 1.02 * 2/12 + 0.18 * 3/12)$$
$$= 5{,}283 \text{ square feet}$$

Where:

A	=	Surface Area
WQ_v	=	Water Quality Volume (or total volume to be infiltrated)
n	=	porosity (g of the gravel, p of the concrete layer)
d	=	depth or gravel layer (feet) (g of the gravel, p of the concrete layer)
k	=	percolation (inches/hour)
T	=	Fill Time (time for the practice to fill with water), in hours

Check of drain time:

depth = 3*12 + 3 inches to sand layer = 39 inches @ 1.02 in/hr = 38 hours (ok)

Overflow will be carried across the porous concrete and tied into the drainage system for the rest of the site.